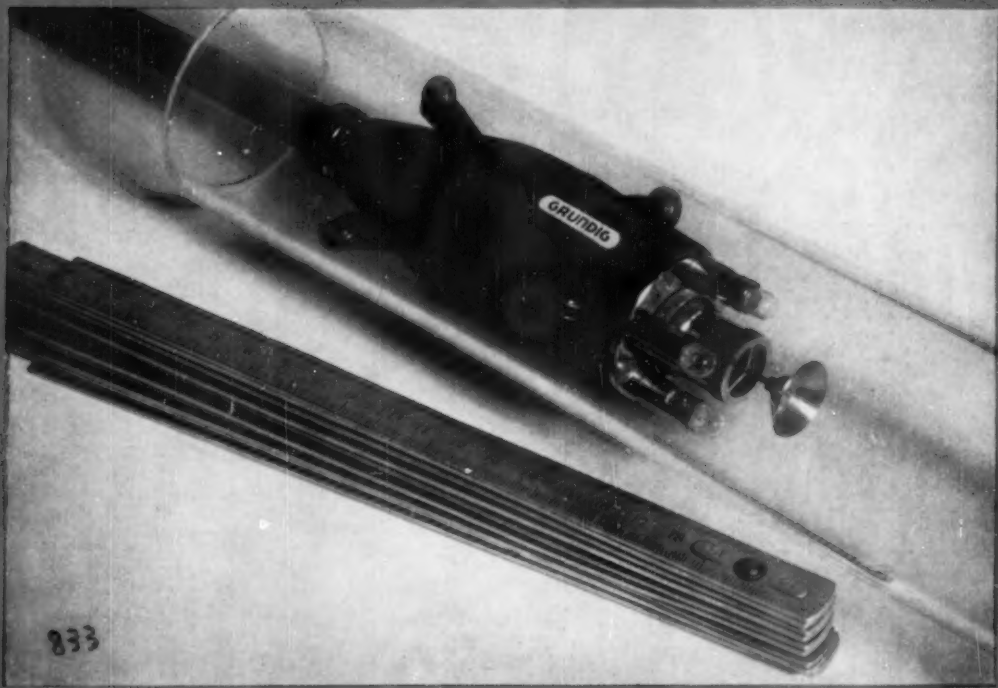
COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

August 1956



Special television camera, 5.9-in. long, 1.85-in. dia., developed in Germany for tube inspection.
(See page 57)

Central Station Power Plant Dust Collectors

A Gas Turbine for Industrial Use

The Supercritical Pressure Plant of Avon, No 8

COMBUSTION

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Vol. 28 **No. 2**

August 1956

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BPA

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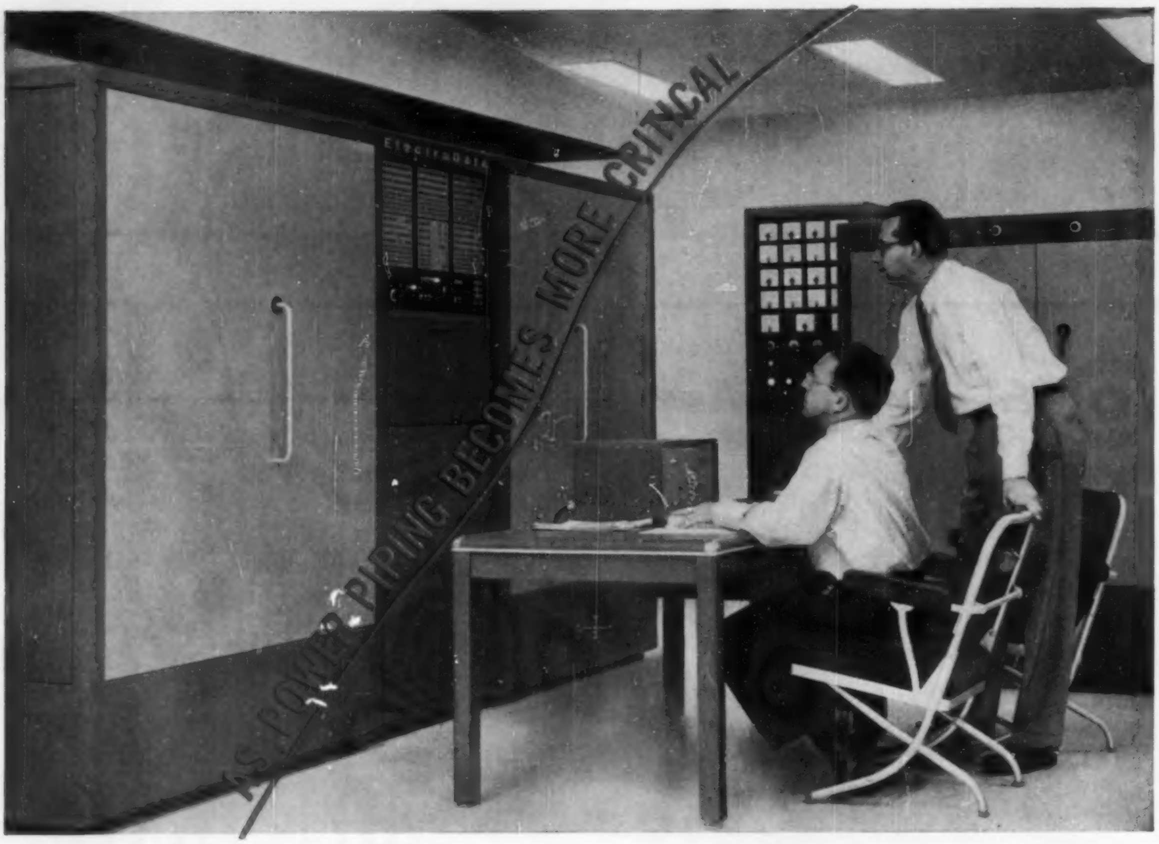

Kellogg's Design Calculation Techniques Keep Pace

Latest and most valuable electronic addition to The M. W. Kellogg Company's facilities for solving the design calculation problems of power piping customers is a new, large magnetic drum digital computer. It can execute 500 arithmetical operations per second; conservatively can solve 40 simultaneous equations in 30 minutes; and has a memory capacity of over 4000 ten-digit words. This computer is now in use at Kellogg's new New York Headquarters, and supplements a smaller computer which has been employed for some time at M. W. Kellogg's Jersey City laboratories.

This new computer enables The M. W. Kellogg Company's engineering staff to undertake a far greater number of precise calculations in less time than ever before and, as a result, to determine the optimum main and reheat steam piping designs for steam-electric power plants in minimum time.

A cordial invitation to see the new Datatron computer at work is extended to consulting engineers, and to engineers of power generating companies and their equipment manufacturers. Appointments may be made by contacting the office of the Sales Manager, Fabricated Products Division, The M. W. Kellogg Company, 711 Third Avenue, New York 17, N. Y.

FABRICATED PRODUCTS DIVISION
THE M. W. KELLOGG COMPANY, 711 THIRD AVE., NEW YORK 17, N. Y.
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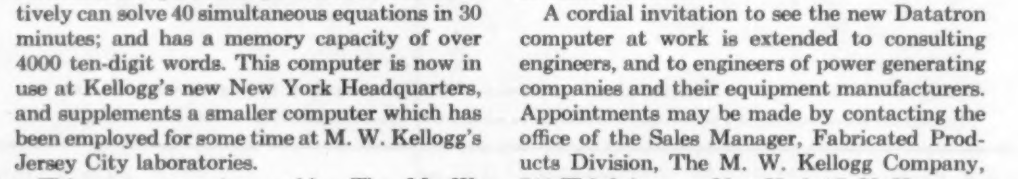
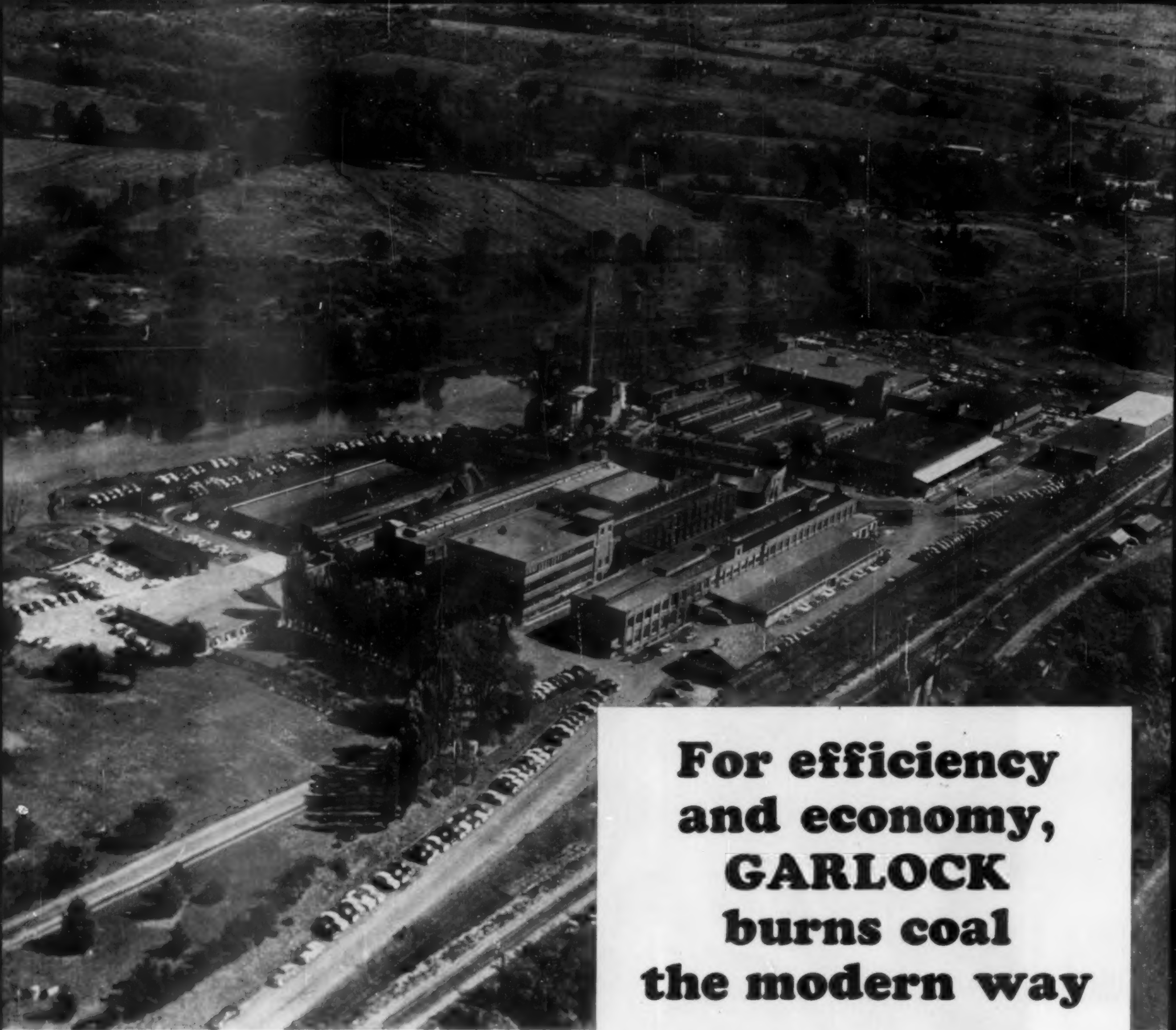


POWER PIPING—THE VITAL LINK



For efficiency and economy, GARLOCK burns coal the modern way

The Garlock Packing Co., Palmyra, N.Y., had a problem common to many growing firms. Production requirements threatened to outpace its power system. Steam capacity and electrical distribution were inadequate; heat balance was poor; equipment was obsolete. Any minor repair or inspection meant curtailed production. So Garlock called in Consultant L. J. Sforzini to study the situation and make recommendations.

The answer was *modernization* and today Garlock burns coal the modern way. A new 100,000 lb.-per-hr. spreader-stoker fired boiler, using older units as standbys, delivers steam for all needs with enough surplus capacity to handle a load growth. Cinder reinjection has improved stoker-firing efficiency. Pneumatic ash handling facilitates overall operation. With these and other changes, Garlock's power plant now operates at peak efficiency and economy.

For further information or additional case histories showing how other plants have saved money burning coal, write to the address below.

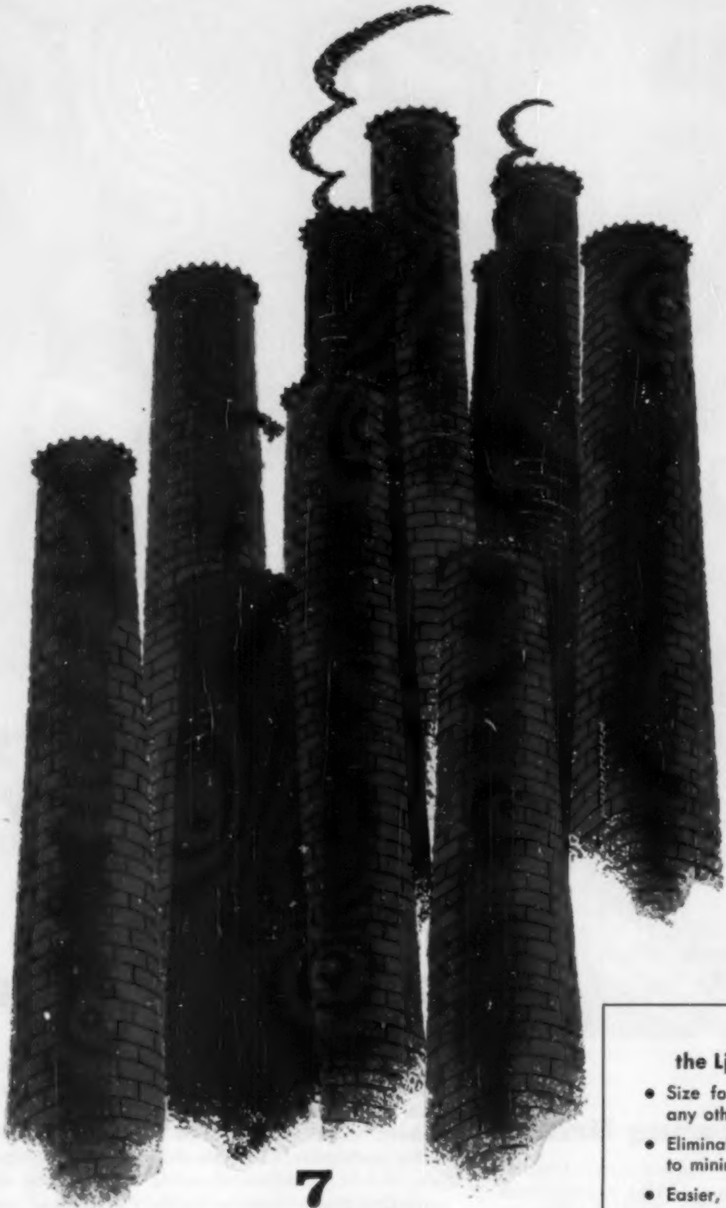
NATIONAL COAL ASSOCIATION
Southern Building • Washington 5, D. C.

Consult an engineering firm

Designing and building hundreds of heating and power installations a year, qualified engineering firms can bring you the latest knowledge of fuel costs and equipment. If you are planning the construction of new heating or power facilities—or the remodeling of an existing installation—one of these concerns will work closely with your own engineering department to effect substantial savings not only in efficiency but in fuel economy over the years.

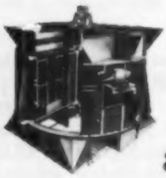
facts you should know about coal

In most industrial areas, bituminous coal is the lowest-cost fuel available • Up-to-date coal burning equipment can give you 10% to 40% more steam per dollar • Automatic coal and ash handling systems can cut your labor cost to a minimum. Coal is the safest fuel to store and use • No smoke or dust problems when coal is burned with modern equipment • Between America's vast coal reserves and mechanized coal production methods, you can count on coal being plentiful and its price remaining stable.



Advantages of the Ljungstrom Air Preheater

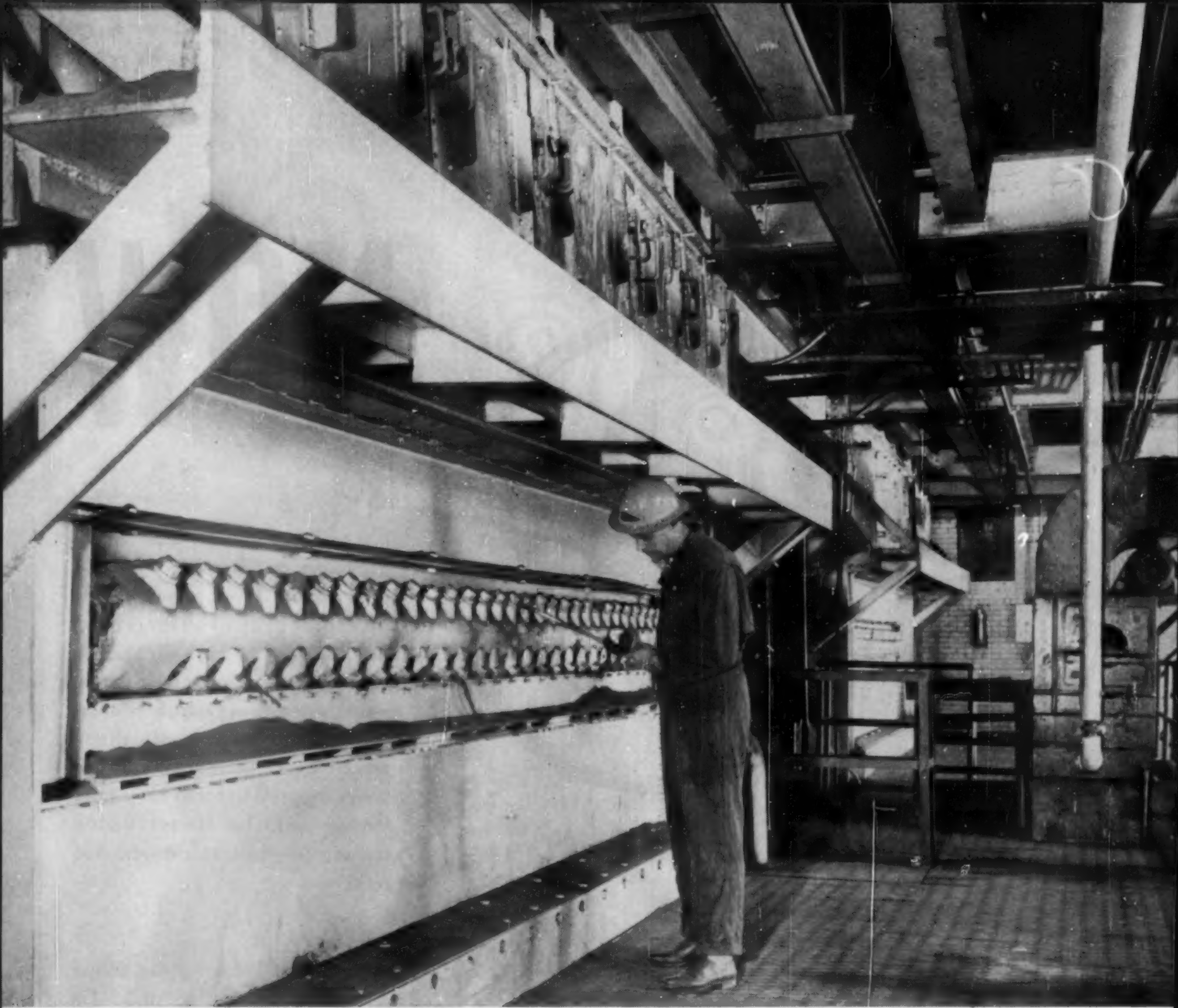
- Size for size, recovers more heat than any other type.
- Eliminates cold spots . . . keeps corrosion to minimum.
- Easier, faster to clean and maintain.
- Requires far less supporting steel and is quickly erected.

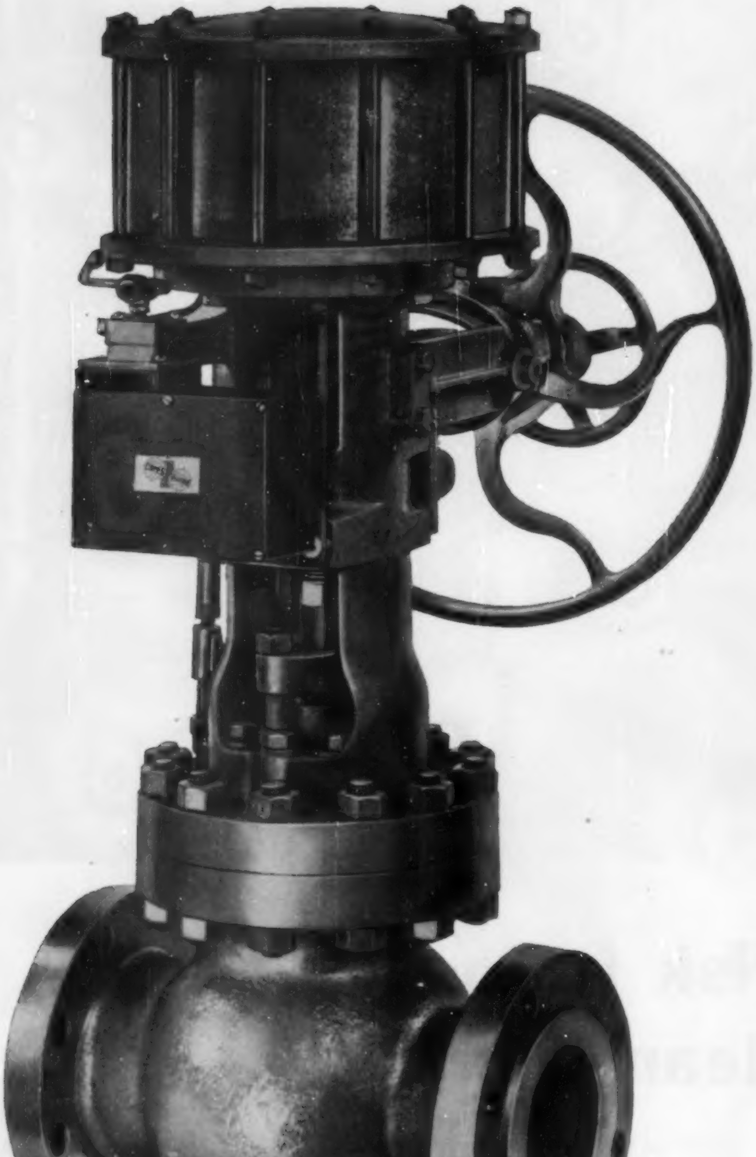


7 out of 10. . . air preheater installations are Ljungstrom®

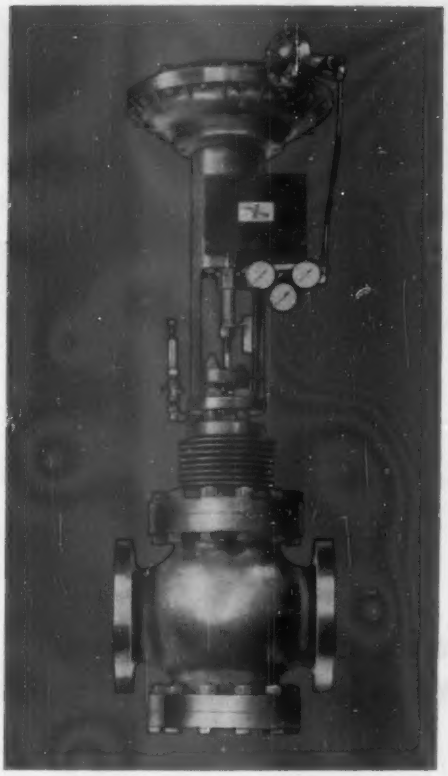
MAXIMUM HEAT RECOVERY is one important reason. As a general rule, a height of one inch of the heating surface used in a Ljungstrom Air Preheater will recover about as much heat as one foot of length of the standard surface of conventional type air preheaters. For the interesting full story, send for a free copy of our 38-page manual.

The Air Preheater Corporation 60 East 42nd Street, New York 17, N. Y.





the right valve for more jobs!



Now you can apply high-quality Copes-Vulcan Valves to any application, at unlimited pressures in sizes up to 12 inches. Simplified design gives you this new versatility, plus high standards of performance for broader applications. Too, you will get the Copes-Vulcan custom-design, with ports exactly suited to the requirements of your operation.

Get in touch with your Copes-Vulcan man. He can help you apply the new Copes-Vulcan Valves to your control requirements. You'll get real dollars-and-cents savings in operational cost with less downtime in even those troublesome spots where ordinary valves are inadequate. Write for Bulletin 1027.

COPES-VULCAN DIVISION

BLAW-KNOX COMPANY

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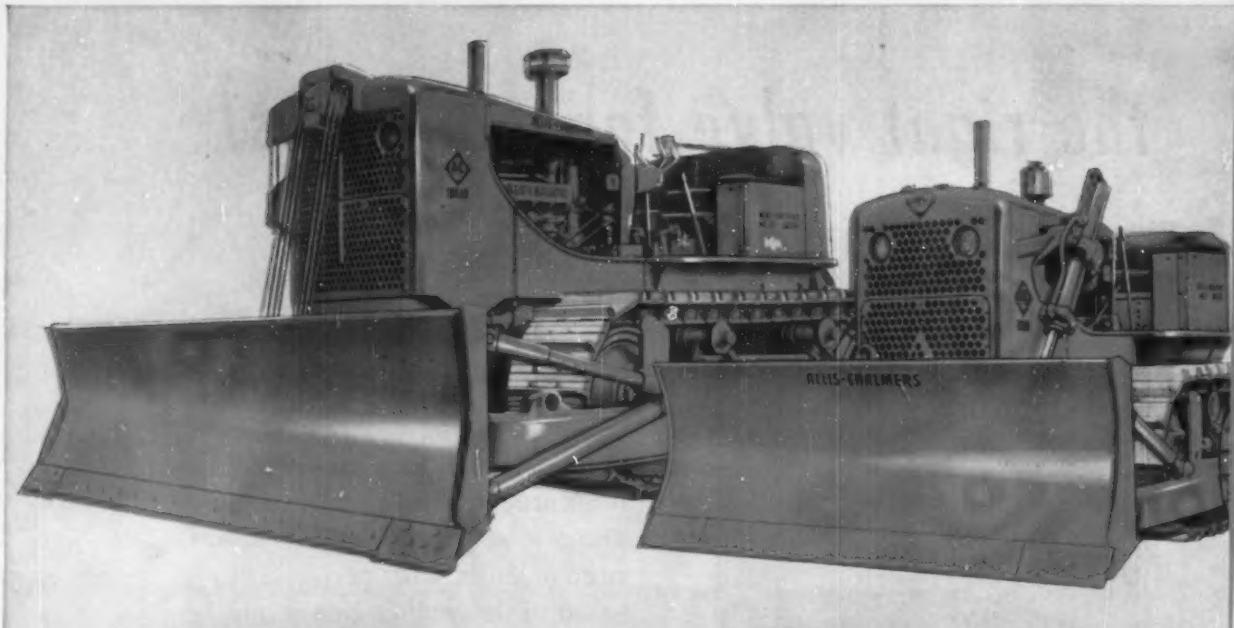
50th Anniversary BLAW-KNOX 1906-1956

Here's why Allis-Chalmers coal handling—give you more



HD-21
204 net engine hp (torque converter drive)
approx. wt (as illustrated) 53,400 lb

HD-11
85 belt hp
approx. wt (as illustrated) 24,600 lb

Advanced basic design makes the difference; look at these specific on-the-job advantages:

All-Steel Backbone for long tractor life. Exclusive box-A main frame absorbs shock loads, protects entire power train.

One-Piece Housing for steering clutches and final drives. It's strong, rigid, to resist twists and shocks . . . line-bored to maintain accurate gear and bearing alignment.

Rugged Final Drives — Small-diameter, double-reduction gears and short, thick shafts are tailor-made for today's bigger loads. Straddle mounting assures proper gear support, eliminates corner loading.

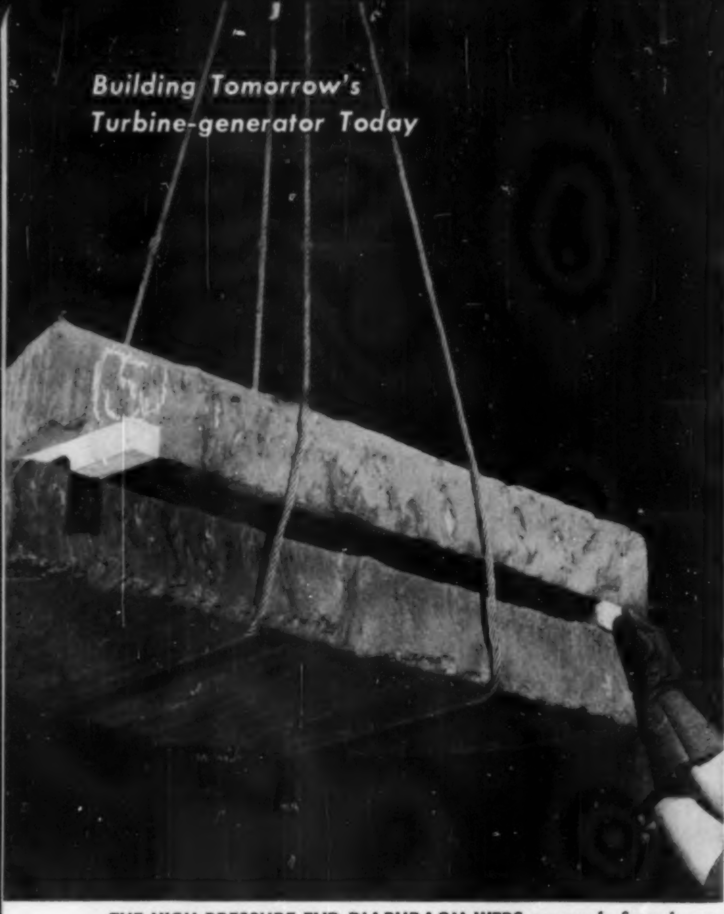
Tough Track — New heat-treating methods mean extra strength, hardness, wearability, long life even under severe conditions.

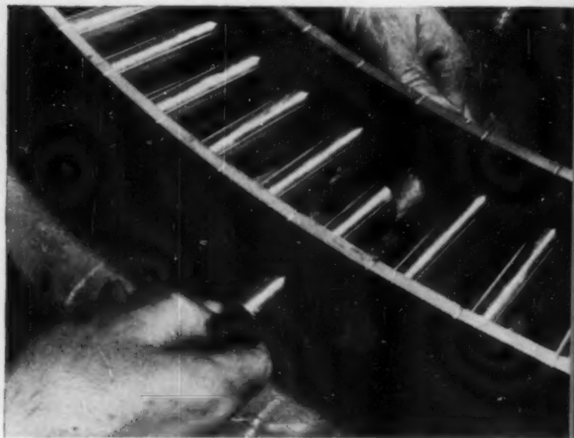
Saved Lubrication Time — On Allis-Chalmers tractors, you grease truck wheels, idlers and support rollers only once every 1,000 hours under any operating conditions—eliminate daily greasing — convert maintenance time into production time.

All-Weather Cooling Capacity — Big, well-protected radiators and cooling systems assure top efficiency and dependability in desert heat or arctic cold.

Wrap-Around Radiator Guard—Built-in dozer mounting reduces cost and weight, produces superior balance of tractor-dozer combination.

Longer-Wearing Master Clutches — Ceramic button lining (on all standard trans-





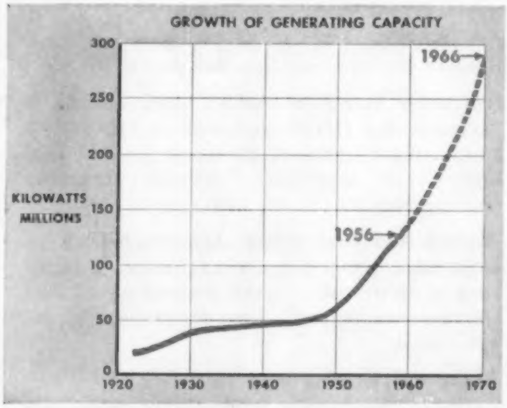
THE HIGH-PRESSURE END DIAPHRAGM WEBS are made from heavy alloy steel plates or castings. Some are ten inches thick and can withstand high pressure drops and maintain close clearances.

THE WEB is then carefully machined for welding (top). Nozzle partitions are machined from solid chrome-iron alloy and assembled in punched bands (bottom).

How General Electric builds sturdy nozzle-

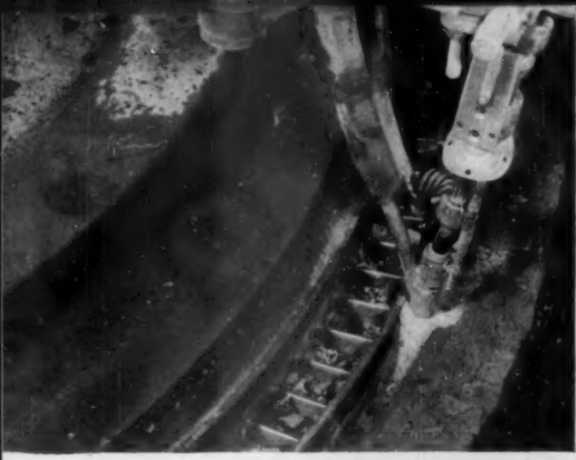
GENERAL ELECTRIC MAINTAINS a continuing program of research on turbine diaphragms. This smoke tunnel provides a visual indication of how steam flow will follow new nozzle designs.

TO MEET TOMORROW'S EXPANDING LOADS

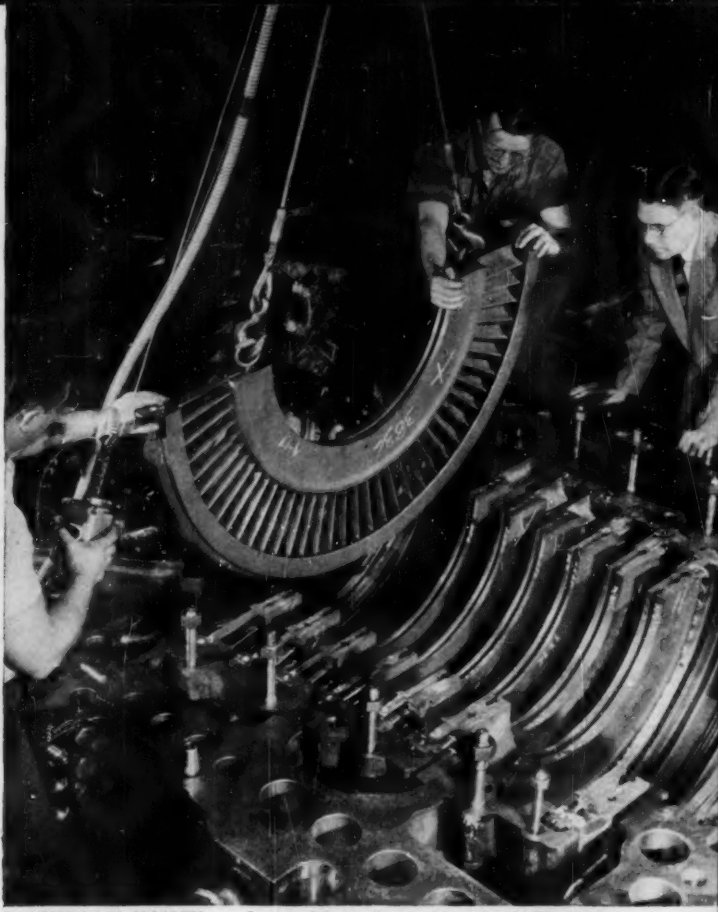


G.E. works with electric utilities and consulting engineers in these vital turbine-generator areas:

- BASIC RESEARCH
- APPLIED RESEARCH
- PRODUCT DEVELOPMENT: **NOZZLE-DIAPHRAGMS**
- TESTING
- MAINTENANCE



THIS NOZZLE assembly is welded to the web and outer ring (top). A finishing operation puts a high polish on the partitions for a smooth steam path (bottom).



DIAPHRAGM HALVES are lowered into the turbine shell. The rotor is then assembled and the upper shell containing the top half of the diaphragm is added to form a series of complete compartments.

diaphragms to reduce turbine maintenance

TOUGH CONSTRUCTION HELPS PROTECT STEAM PATH AGAINST DESTRUCTIVE FOREIGN MATERIALS

Internal damage to the steam path can be a costly and time consuming cause of turbine shutdown. Should large amounts of foreign material enter the steam path whole rows of buckets and partitions might be severely damaged. This could mean a long and costly outage.

TO HELP GUARD against a long outage, General Electric builds turbine nozzle-diaphragms of tough, sturdy construction. And here's how they help. Should foreign materials enter the steam path, these rugged nozzle-diaphragms "compartmentalize" damage to a small area. This greatly simplifies bucket repairs or replacement.

GENERAL ELECTRIC MANUFACTURES these diaphragms from solid castings or plates carefully machined to shape. Nozzle partitions are machined from solid chrome-iron alloy and welded to, or cast integral with, the webs. These partitions must direct the steam flow at the proper angle and velocity to the adjacent buckets.

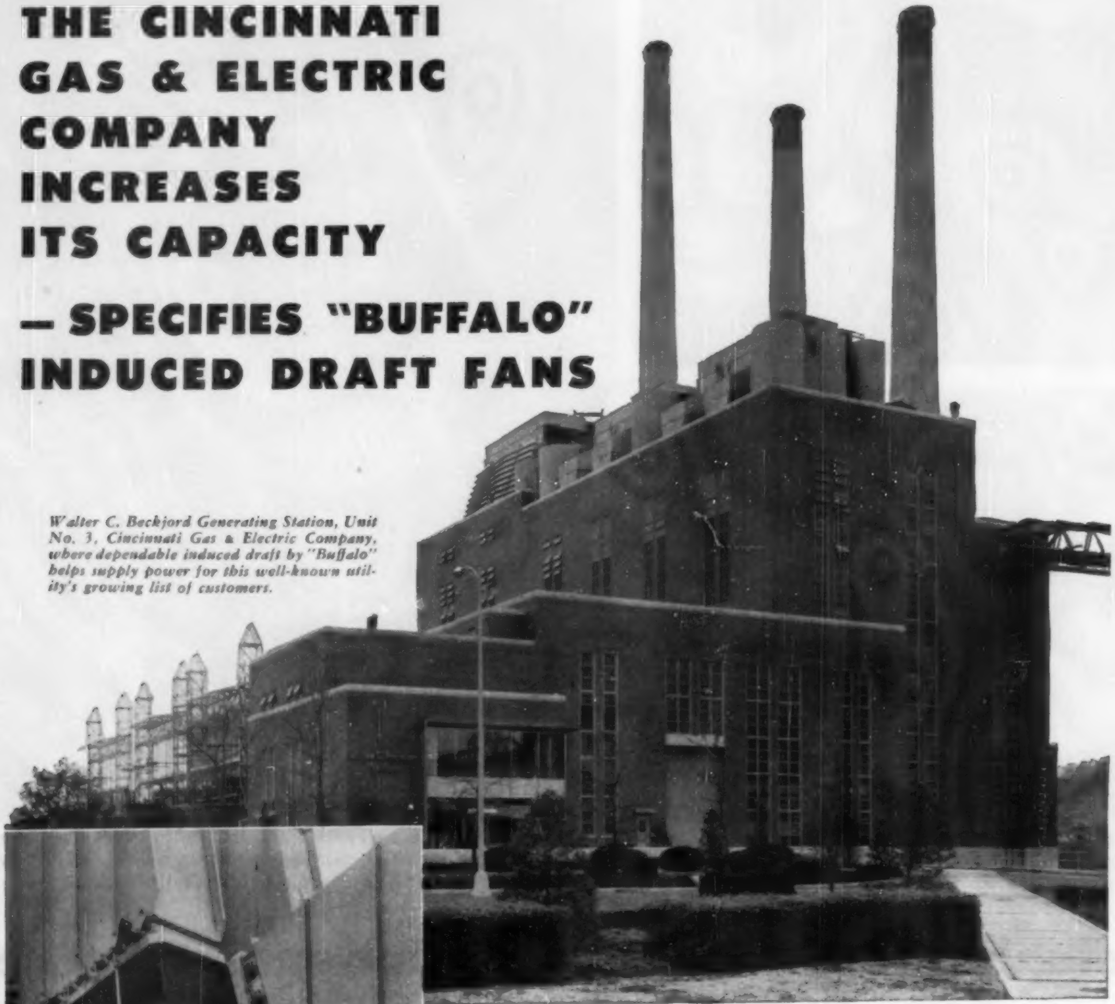
In this and many other areas of research G.E. is working with electric utilities and consulting engineering firms to design the power makers for tomorrow's load growth. For more information on General Electric turbines write for GER-905, Large Steam Turbine-Generator Department, General Electric Company, Schenectady 5, N. Y. 234-40

Progress Is Our Most Important Product

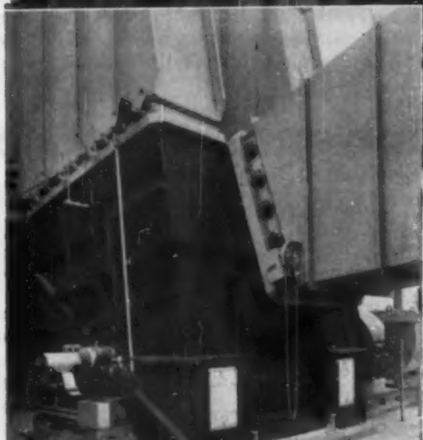
GENERAL ELECTRIC

THE CINCINNATI GAS & ELECTRIC COMPANY INCREASES ITS CAPACITY

— SPECIFIES "BUFFALO" INDUCED DRAFT FANS



Walter C. Beckjord Generating Station, Unit No. 3, Cincinnati Gas & Electric Company, where dependable induced draft by "Buffalo" helps supply power for this well-known utility's growing list of customers.



"Buffalo" I. D. Fan at Walter C. Beckjord Generating Station, Unit No. 3. Note heavy, reinforced construction of inlet boxes and housing. Inlet dampers provide instant, positive draft control to match load. Heavy-duty self-aligning bearings are water-cooled. Fan wheels and housings are engineered to resist effects of heat and erosion.

ADDITIONAL "BUFFALO" FANS ORDERED FOR ANOTHER UNIT TO START UP IN DECEMBER 1957

The Cincinnati Gas & Electric Company, pushing through its ambitious program of expanded service, specified "Buffalo" I. D. Fans for both this new Unit No. 3 station and Unit No. 4 which will be operating in 1957.

Selection of "Buffalo" by leading utilities for many, many years is your assurance of dependable, economical draft service. In fact, the "Buffalo" Mechanical Draft Fan you specify embodies the best of our 79 years of fanmanship — peak endurance, peak efficiency for its job — in other words, the "Q" Factor* that's built into every "Buffalo" Fan. You'll be interested in our new, improved lines of forced and induced draft fans — write for engineering data today!

**The "Q" Factor — the built-in Quality which provides trouble-free satisfaction and long life.*

BUFFALO FORGE COMPANY

BUFFALO, NEW YORK

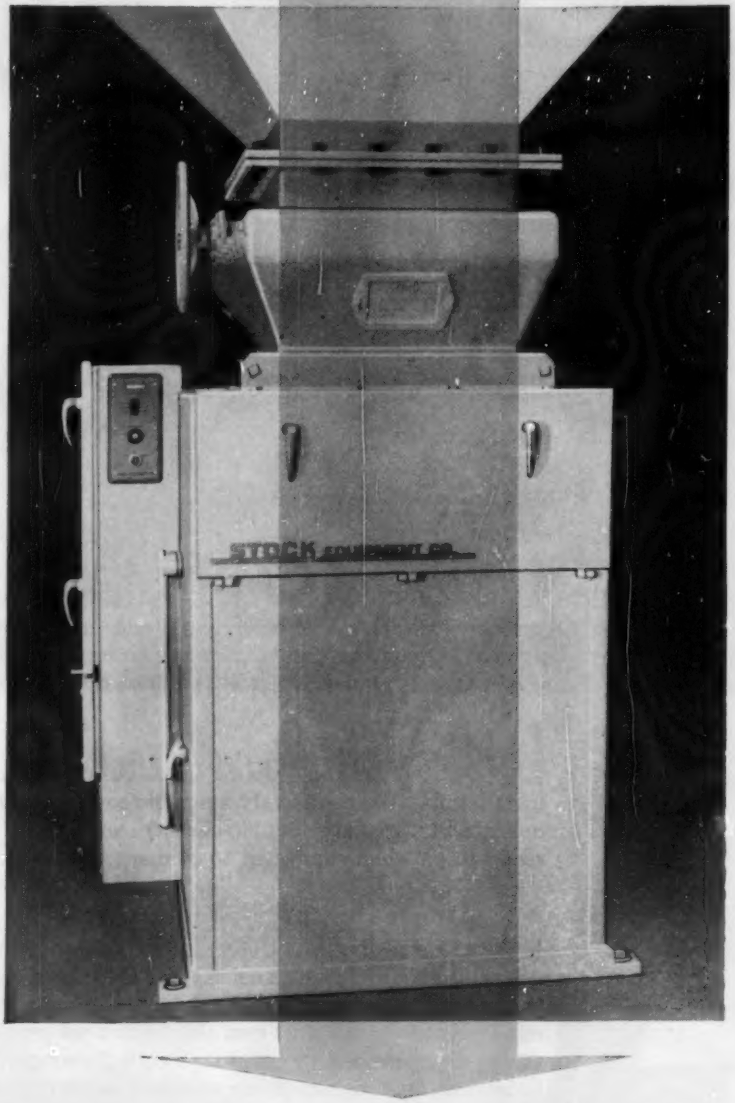
"Buffalo"

Canadian Blower & Forge Co., Ltd., Kitchener, Ont.

VENTILATING   AIR CLEANING   AIR TEMPERING   INDUCED DRAFT   EXHAUSTING   FORCED DRAFT   COOLING   HEATING   PRESSURE BLOWING

THE NEW S-E-CO. MODEL 50

COAL SCALE is the only scale that carries a 24" width of coal through the scale without restriction



To meet the requirements of central stations and industrial plants that are using larger and larger boilers — and to move coal that is becoming more and more sluggish — Stock Equipment Company has developed their new Model 50 Automatic Dust-Tight Coal Scale.

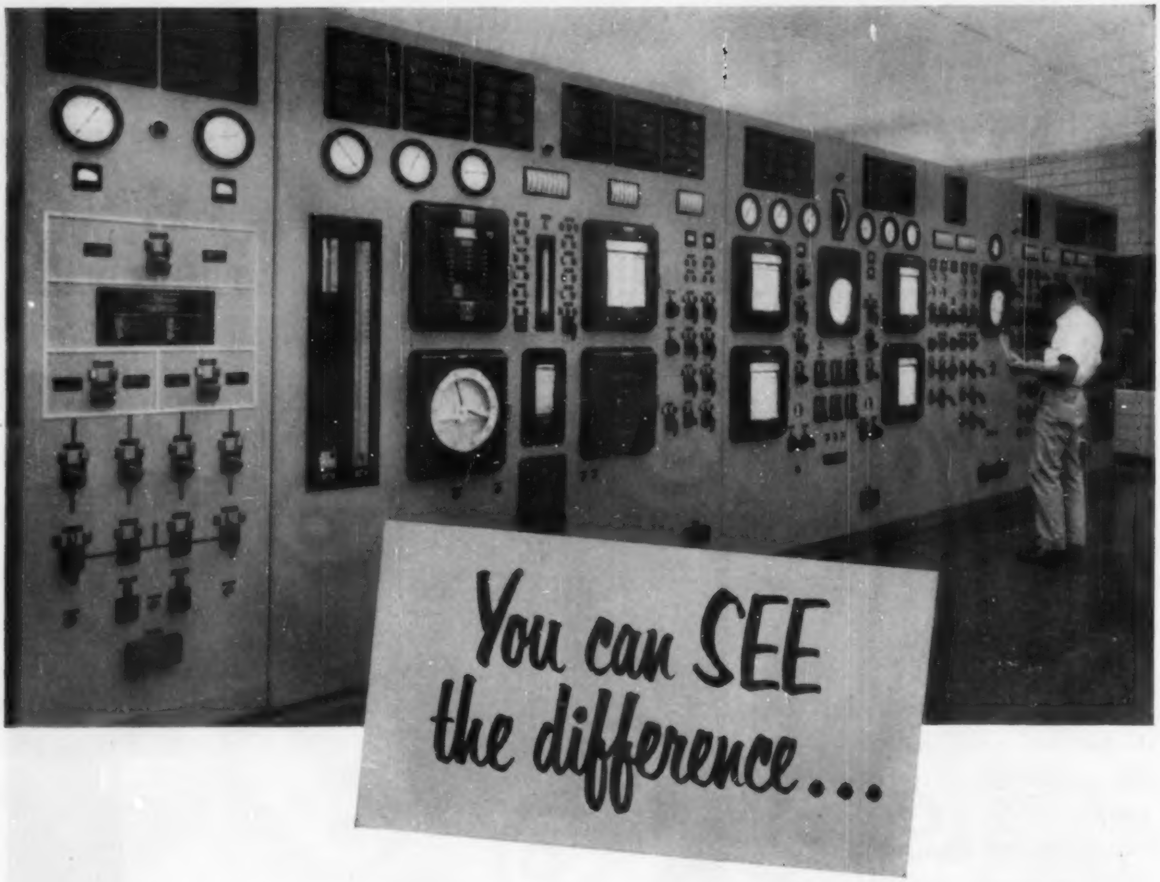
The inlet is a full 24" inside square and the feed belt carries the coal straight through in an unrestricted 24" stream. The belt has the well known S-E-Co. endless, molded construction and is carried on closely spaced anti-friction idlers. This design allows it to handle the inlet loading (even under the largest bunkers) without danger of belt failure or shortened life.

The Model 50 includes many other new and advantageous features. Contact the Main Office in Cleveland or any of the local representatives to arrange for a conference to discuss these features in detail. Your next unit, whether it's brand new or part of a rebuilding program, deserves and needs the new S-E-Co. Model 50.

SPECIALISTS IN
BUNKER TO PULVERIZER AND
BUNKER TO STOKER EQUIPMENT

STOCK Equipment Company

745-C HANNA BLDG., CLEVELAND 15, OHIO



L+N complete panels serve the needs of your operating personnel. Each panel is designed and custom-built to your requirements. Instruments and controls are arranged in a functional pattern for easy reading . . . assist in reducing fuel costs and operating errors.

L+N complete panels save time and costs for your panel installation. We completely assemble each panel in our plant, with all instruments in place, double-checked and tested. You receive panels ready to go when connected to primary elements and control devices.

L+N complete panels solve your panel engineering and design problems. Our panel engineers convert your requirements for control of boiler, turbine and auxiliary equipment into a functional layout for your approval. From this layout we prepare the electrical and piping diagrams and the final steelwork drawings. You receive prints of these drawings as part of our standard panel engineering service.

***Let an L&N panel engineer** study your problems; he'll explain in detail what we can do for your particular plant. Our fifteen years in building panels for many utilities assures you of effective service. Write to Leeds & Northrup Company, 4972 Stenton Avenue, Philadelphia 44, Pa.*

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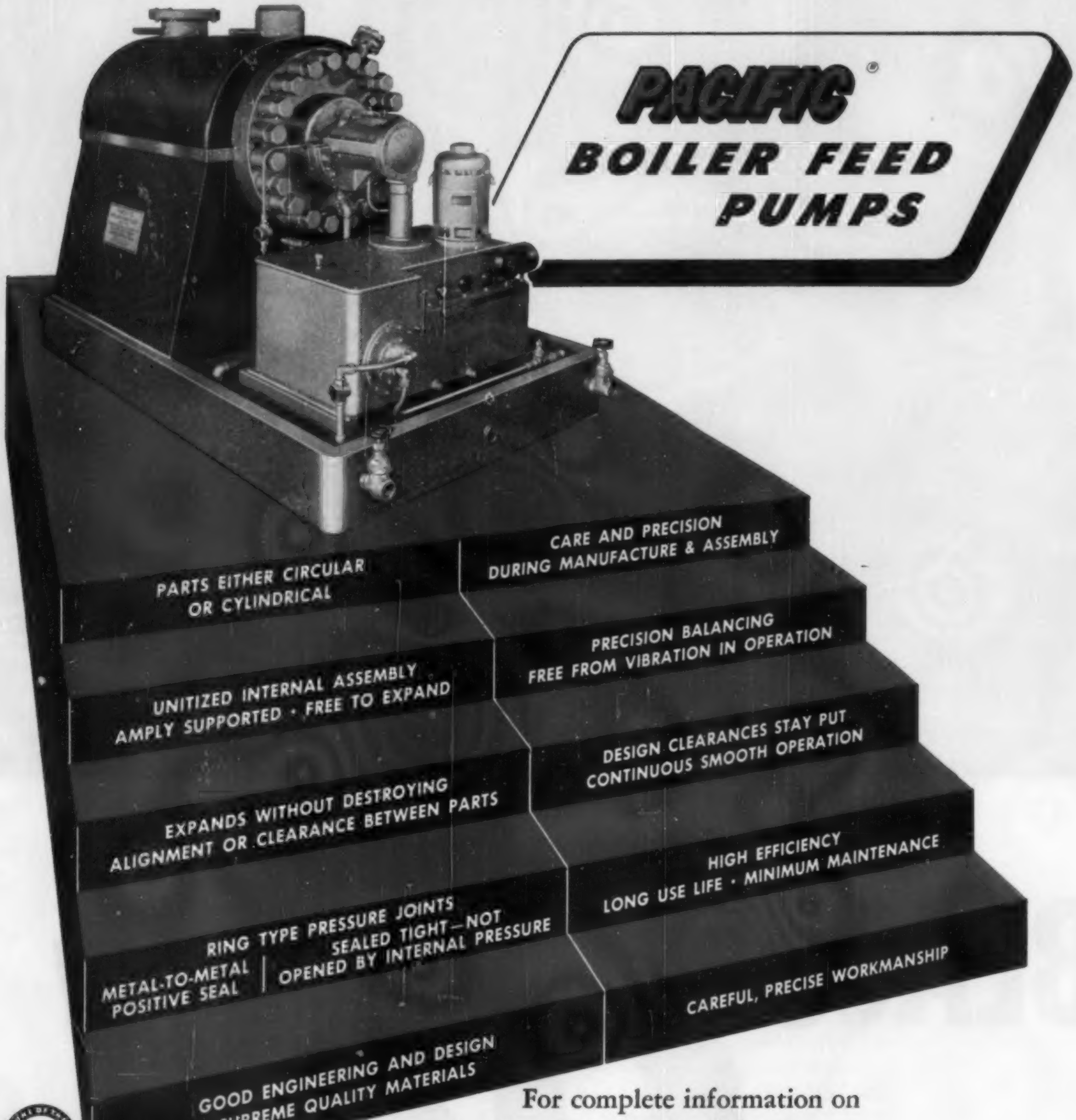
instruments *automatic controls • furnaces*

Built on an Unassailable Foundation



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Pacific Boiler Feed Pumps
Write for Bulletin 122.

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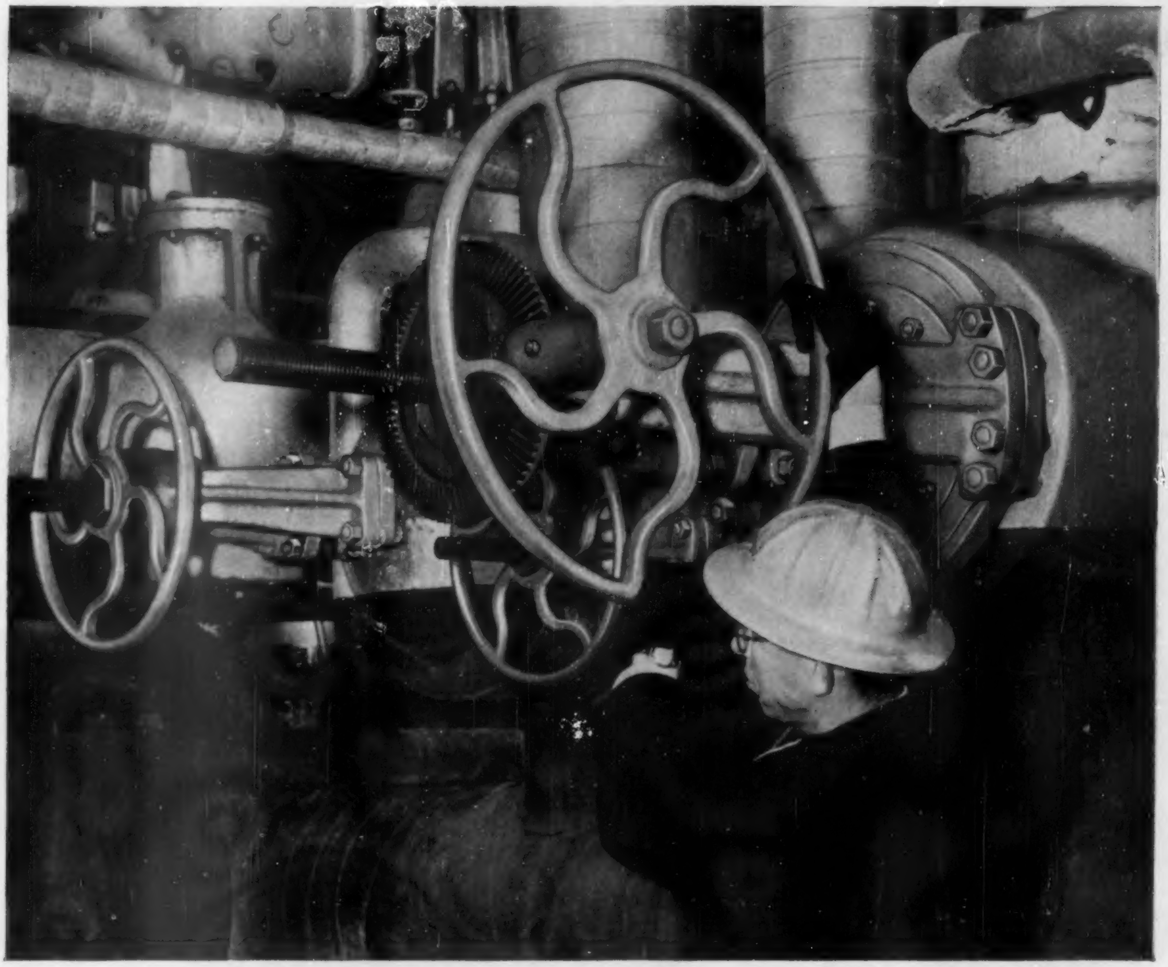


12 years' cost-free service completed by this Crane valve on saturated steam

Since 1944, this Crane 16-inch Pressure-Seal gate valve has been handling 450 psi saturated steam. It's working as a stop valve on a header in the Neches Butane Products Company's butadiene plant in Texas.

When opened for inspection recently—after 12 years of hard service—this rugged Crane valve was found to be in perfect condition. Not once has it leaked or needed maintenance at the bonnet joint or seat.

Here's why: instead of depending on bolting to retain pressure, the Crane Pressure-Seal bonnet design utilizes internal fluid pressure to make a leak-free, maintenance-free joint. And with the Crane flexible wedge disc—self-adjusting to temperature changes—sticking of the disc is eliminated, and operation is always smooth and easy.

Because they're so trouble-free, and so compact and streamlined (saving line weight and simplifying insulation), Crane Pressure-Seal Bonnet Valves are giving consistent satisfaction on high-pressure, high-temperature power plant service. Get full information from your local Crane Representative, or write to address below.

CRANE VALVES & FITTINGS

PIPE • KITCHENS • PLUMBING • HEATING

Since 1855—Crane Co., General Offices: Chicago 5, Ill. Branches and Wholesalers Serving All Areas

GAS FIRED BOILERS

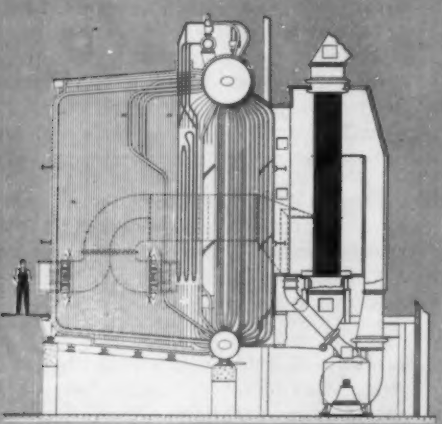
The boilers illustrated here cover the broad capacity range from 4,000 to 600,000 lb of steam per hr. They are all especially designed for gas and/or oil firing. The two units shown on the left page (Types VP and VU-55) are standardized and each is available in several sizes. The capacity range covered by these two units is from 4,000 to 120,000 lb per hr. The two units below are custom designed for various capacity, pressure and temperature requirements up to 600,000 lb per hr, 1400 psi and 950 F. All these units are pressure fired and do not require induced draft fans.

Collectively, they offer an exceptional diversity of choice. A brief consideration of the features of each type will help you "pinpoint" the design characteristics best suited to your particular needs.

Of course there are other C-E two drum Vertical-Unit Boilers available for pressures up to 1400 psi and temperatures up to 960 F. Shown here are but four popular members of the C-E family of Vertical-Unit Boilers—a family which has achieved a wide measure of acceptance using all types of fuel.

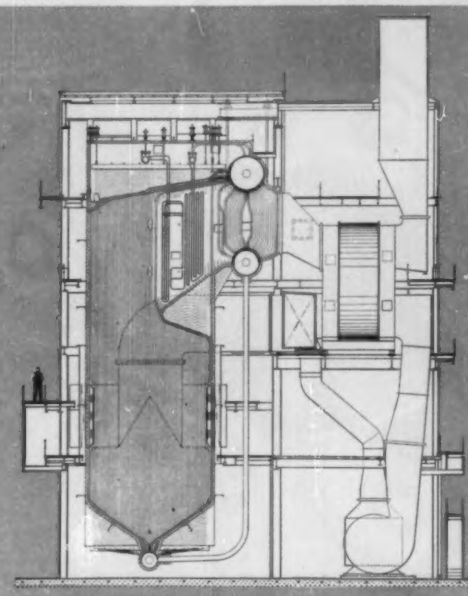
Please feel free to call on us for further detailed information. Catalogs are available upon request.

B-922



C-E Vertical Unit Boiler—Type VU-50B

This unit is available for capacities from 50,000 to 400,000 lb per hr—pressures to 1400 psi and temperatures to 950 F. This bottom-supported design uses tilting tangential burners providing effective superheat control. Horizontal burners can be furnished if desired. Heat recovery equipment as required. This unit makes available to industrial installations a standard of performance comparable to utility practice.



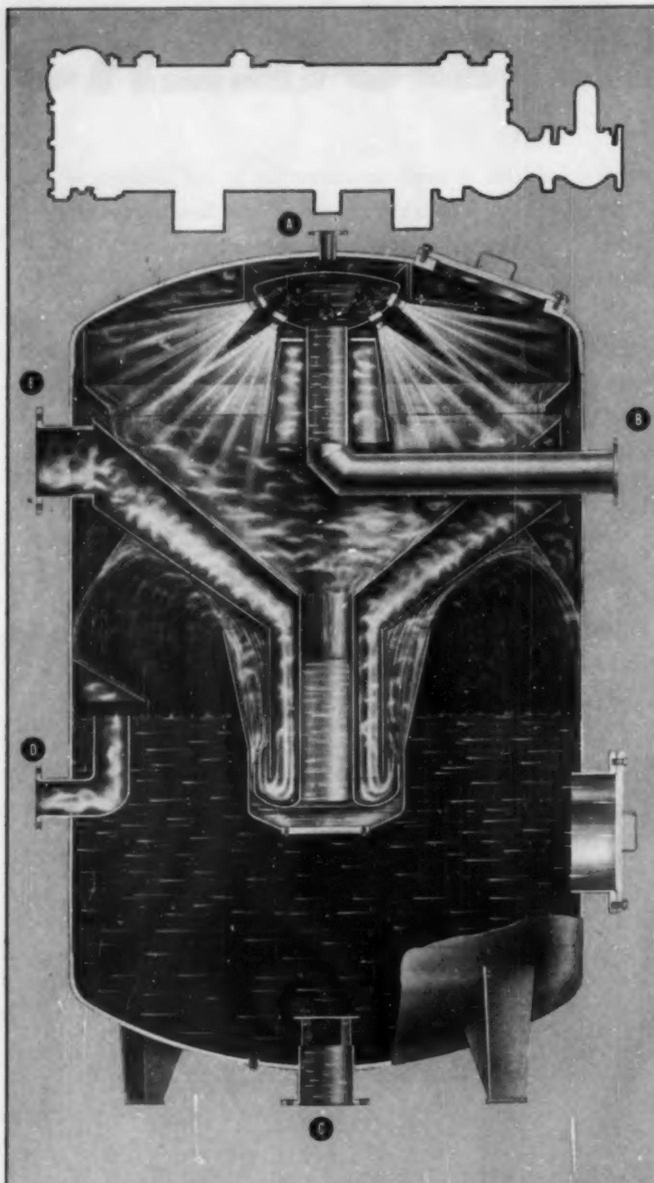
C-E Vertical Unit Boiler—Type V2

This unit is available for capacities from 200,000 to 600,000 lb per hr. It can be designed for pressures up to 1400 psi and for temperatures to 950 F. Tilting tangential burners, providing superheat control, are standard equipment although horizontal burners are available, if desired. A double, gas-tight casing assures lifetime tightness and minimum heat loss. Heat recovery equipment can be furnished as desired.

ENGINEERING CE

200 Madison Avenue, New York 16, N. Y.

SYSTEMS • PRESSURE VESSELS • HOME HEATING AND COOLING UNITS • DOMESTIC WATER HEATERS • SOIL PIPE



Full-contact deaerator needs no external vent condenser (white outline). The full-contact design effectively concentrates the vent-mixture inside the deaerator shell.

- (A) Vent to atmosphere
- (B) Water inlet
- (C) Pump suction connection
- (D) Overflow connection
- (E) Steam inlet

WORTHINGTON

Now! Do away with deaerator maintenance

Here's a modern deaerator that eliminates most service problems because it has no vent condenser.

Virtually eliminates maintenance. Crammed up against the ceiling, vent condensers are difficult to inspect and clean. With a Worthington full-contact deaerator you eliminate this trouble and expense. For plants that normally operate around the clock, shutdown for deaerator maintenance is rarely necessary.

The carefully proportioned displacement flow path provided in the full-contact design concentrates the vent mixture by direct contact inside the deaerator shell. The vent condenser is no longer necessary.

Saves space. Headroom required by the deaerator may be cut by several feet—an important consideration in today's modern power plants where space is at a premium.

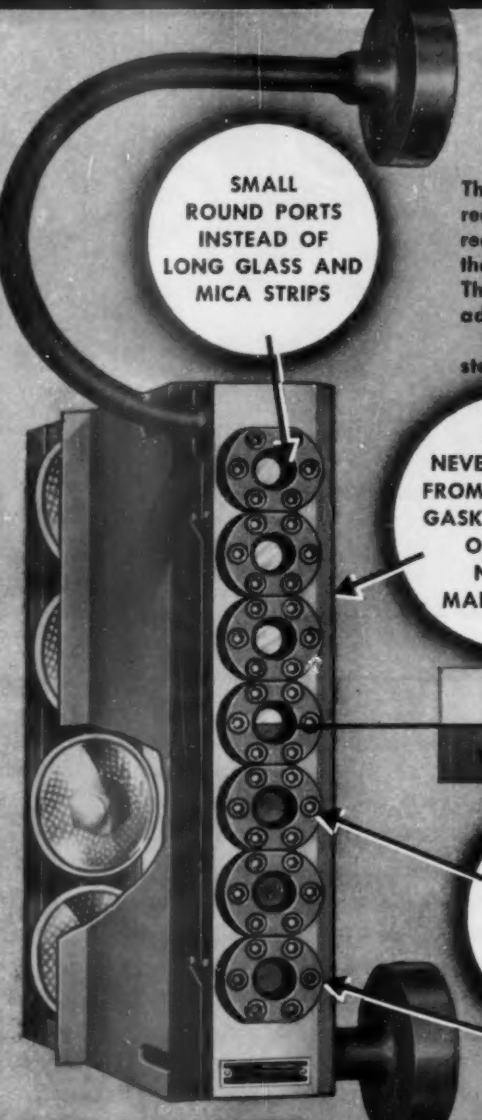
High efficiency. Like all Worthington deaerators, the full-contact unit is highly efficient at light as well as full load, as confirmed by numerous field tests.

Full-contact deaerators in various shell arrangements are available in capacities from 2,000 to 3,000,000 pounds per hour. Bulletin W-210-B32 has complete details. Incidentally, for the small power plant, Worthington builds a line of low-headroom deaerators that eliminate expensive elevated construction. For details, write to Section S66, Worthington Corporation, Steam Power Dept., Harrison, N. J. In Canada: Worthington (Canada) 1955, Ltd., Toronto, Ont. S.6.6

MAKING Great Savings in GAUGE MAINTENANCE

(BOTH TIME AND COST)

DIAMOND "Multi-Port" BI-COLOR GAUGE



The Diamond "Multi-Port" Bi-Color Gauge makes startling reductions in maintenance costs. In cases where accurate records have been kept, labor and material costs are less than 1/5 the maintenance of conventional open port gauges. This is due to the unique design . . . note particularly the advantages that are pointed out on the photograph.

The "Multi-Port" operates on the Bi-Color principle . . . steam always shows red . . . water always shows green. There can be no question of water level. The gauge has been in continuous successful high pressure operation for more than three years in leading central station plants. Users report excellent readability and exceptionally high availability as well as important reductions in maintenance. Return the coupon below to get a copy of Bulletin 1174.

7320

DIAMOND POWER SPECIALTY CORP.
LANCASTER, OHIO

DIAMOND POWER SPECIALTY CORP. V
LANCASTER, OHIO

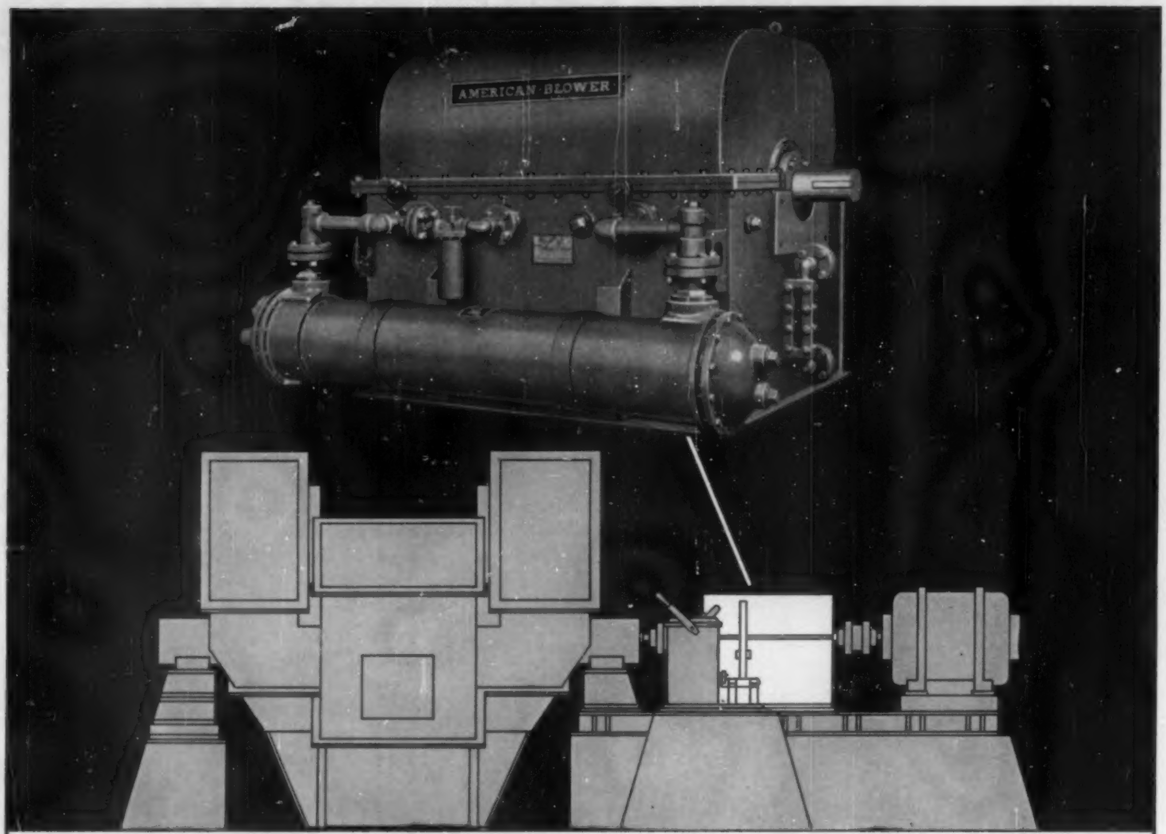
Please send me without obligation a copy of new Bulletin No. 1174 explaining the advantages of the Diamond "MULTI-PORT" Bi-Color Gauge.

NAME____________________

COMPANY____________________

ADDRESS____________________

The tougher the duty, the more



Mechanical Draft Fan | Gýrol Fluid Drive | Motor

LARGER MECHANICAL DRAFT FANS — Gýrol Fluid Drive gives you the kind of accurate, efficient control of mechanical draft that results in important power savings, longer equipment life. The reason: Fluid Drive's infinitely adjustable speed control, which enables each fan to operate at its optimum design or selection point.

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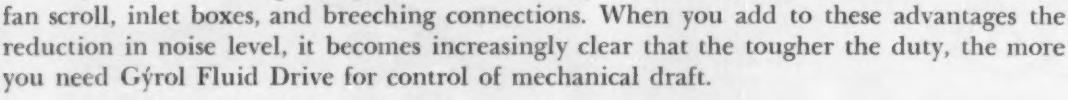

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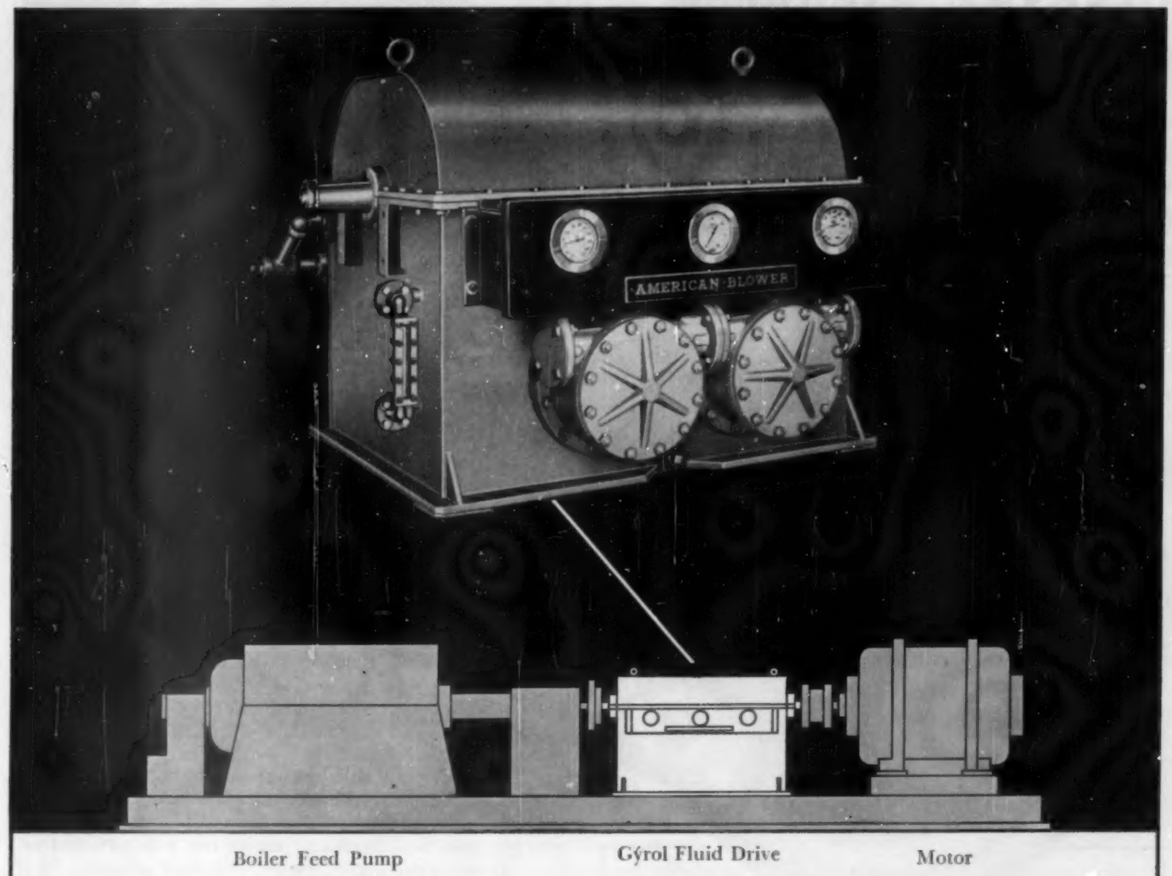

LARGER BOILER FEED PUMPS — As larger boiler feed pumps are built, there is a greater need for higher efficiencies and more accurate control. That's why more and more consulting and utility engineers are recommending Gýrol Fluid Drive.

You see, Gýrol Fluid Drive offers adjustable-speed pump control that saves power over the entire operating range by eliminating wasteful throttling. Then, too, Fluid Drive reduces wear on bearings and other vital parts by operating the pump at speeds that fit boiler demands. Paralleling of pumps is simplified. And emergency changeover from operating to standby pump is fast and foolproof—there's no need for boiler shutdown.

If your plant expansion calls for boiler feed pump control, it will pay you to talk to an American Blower engineer. He can show you where Gýrol Fluid Drive can save power, cut costs, give you a more efficient operation. Contact our nearest branch office, or write us direct. American Blower Corporation, Detroit 32, Michigan. In Canada: Canadian Sirocco Company, Ltd., Windsor, Ontario.

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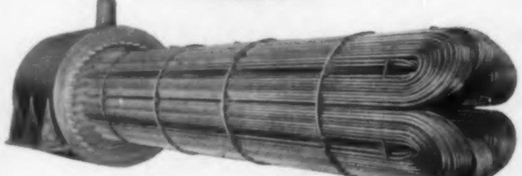

Every length of Standard Boiler and Pressure Tubing is tested at pressures far beyond code requirements and can be readily bent or otherwise fabricated.

Electric welded boiler tubing is used today by all of the leading manufacturers of boilers and superheaters—stationary, marine, and locomotive—high or low pressure—and meets the requirements of government and commercial specifications.

With recent changes in the A.S.M.E. Boiler Code, it's now possible to use electric weld boiler tubing at pressures in excess of 2,000 lbs. High strength "Grade C" tubes are available for even higher pressures.

Uniformity of temper and wall thickness makes Standard tubes easier to roll for tight . . . sure fit. Standard's fine, smooth surface eliminates any need to polish ends for tight fit. Even a microscope won't spot the exact location of the weld.

Nowhere will you find any more modern and complete facilities for precision manufacture and inspection of Boiler and Pressure Tubing than you'll find at Standard.

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Welded stainless tubing and pipe • Welded carbon steel mechanical • Boiler and Heat Exchanger • Exclusive rigidized patterns • Special Shapes • Steel Tubing – Sizes: ⅛" OD to 5⅛" OD – .028 to .260 wall • Stainless – Sizes: ¼" OD to 4½" OD – .020 to .165 wall.

Hall Industrial Water Report

VOLUME 4 | AUGUST 1956 | NUMBER 4

Scale or Sludge Deposits Can Crop Up Most Anywhere Water is Used

When they do, the water detective must find the cause and the cure. Sometimes the problem is run-of-mine. More often, however, it brings into play his skill and experience as a specialist in dealing with water.

Cold Niagara Revealed as Offender

As winter cold deepened, a chemical manufacturing plant on the Niagara River, a Hall client for many years, suddenly experienced a hard glassy deposit in the plant intake and distribution system. Pumps had to be removed from service for cleaning. Mechanical cleaning had no effect, but when the pumps were heated with steam the deposit softened and washed out.

G. H. Smith and R. E. Elliott, Hall engineers in the Buffalo office, found that the Niagara River water at the plant intake showed greater than normal values for calcium, alkalinity and pH, indicating contamination by an alkaline calcium-bearing material. However, this information did not explain the fact that calcium carbonate was being deposited in the cold sections of the system rather than at points where the water was being heated.

Elliott called J. P. Kleber at the home office in Pittsburgh for an opinion. From past experience, Kleber had the answer immediately. Hexahydrate of calcium carbonate!—a quite uncommon material. Temperatures below 40F plus some free hydroxide alkalinity in Niagara River water had precipitated this compound. When the temperature was elevated, the material lost its water of hydration and left a relatively soft calcium carbonate mud.

How to prevent the deposit? Nothing could be done about the contamination or the winter temperature of the incoming water. While treatment of this water with 5 ppm of Calgon® would keep the scale from forming, in-plant changes appeared to be less costly than chemical conditioning. Well-pleased with the diagnosis and suggestions, the plant went ahead with these changes.

Desuperheater Develops Deposit

At a lumber plant in Oregon a low-pressure turbine using desuperheated steam suffered a substantial decrease in capacity. Inspection of the desuperheater and the steam line beyond it revealed the presence of deposits an inch thick.

R. T. Manion, Hall field engineer in Portland, uncovered the fact that during the night there was insufficient condensate for desuperheating, so raw water was being used to supplement it. Evaporation of this raw water deposited the solids it contained in the desuperheater, steam lines and turbine.

Further investigation produced a practical answer to the problem. During the day there was more condensate than required for desuperheating, so Manion recommended storing the excess for use at night. Now the plant has sufficient condensate for desuperheating at all times. As a result, turbine capacity remains constant and the former difficulties with valves, strainers and traps are no longer experienced. A recent inspection of the desuperheater showed it to be clean.

Midwest Power Co-operative Eliminates Manual Cleaning Of Preheater Trays

Hand chipping of hard, white scale from their evaporator preheater trays was a time-consuming monthly task at a midwest power co-operative. J. F. Nelson, Hall field engineer in Kansas City, suggested changes in points of chemical feed ahead of the preheater in order to obtain good mixing of the conditioning chemicals before the water reached the preheater. He further recommended the feeding of 5 ppm of Hagan Dispersive®.

Since the start of dispersive feed a 30 percent increase in evaporator capacity has been noted because of cleaner heat transfer surfaces. Also when the preheater trays were cleaned after three months' operation the deposit found was so soft it could be removed with the fingers. Further changes have been recommended which should result in even greater improvement in conditions.

Hospital Reports Condition Of Boilers Excellent

When a hospital on Long Island, New York, decided to increase steam generating capacity, Hall Laboratories was invited to provide water conditioning service for the expanded boiler plant.

Hall field engineer R. A. Beardsley found that the old boilers contained a considerable amount of scale difficult to remove by mechanical cleaning even though the make-up water had been zeolite softened and phosphate and soda ash had been used for internal conditioning. Serious tube difficulties had been averted simply because the boilers had been operated at very low ratings.

After three years of cooperative effort with Beardsley, the Chief Engineer at the Hospital reports, "The new boilers are free of scale and corrosion. The scale has been removed from the old boilers and it is now possible to operate during the off-heating season with only one boiler at greatly increased fuel efficiency."

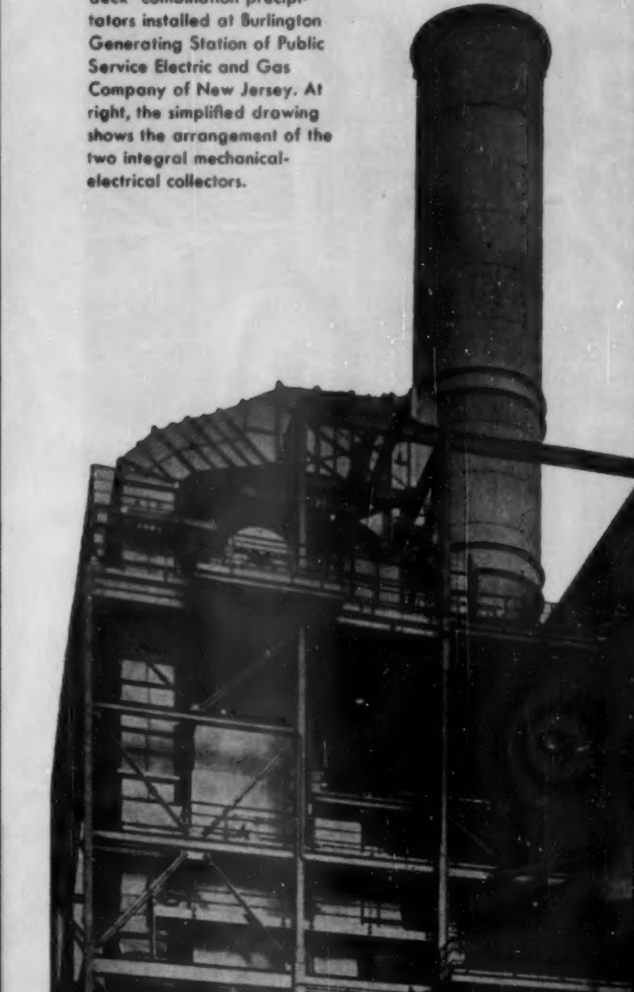
Industrial Water Problems Require Special Handling

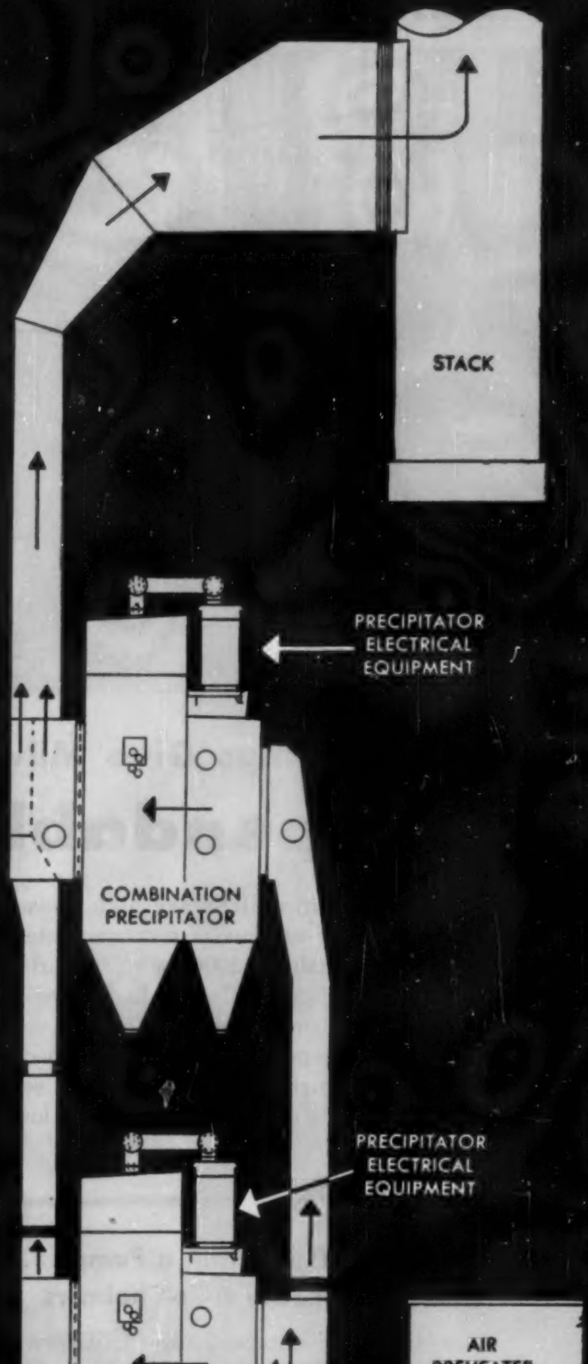
There are no "stock answers" to industrial water problems. For information write, wire or call Hall Laboratories, Inc., Hagan Building, Pittsburgh 30, Pa.

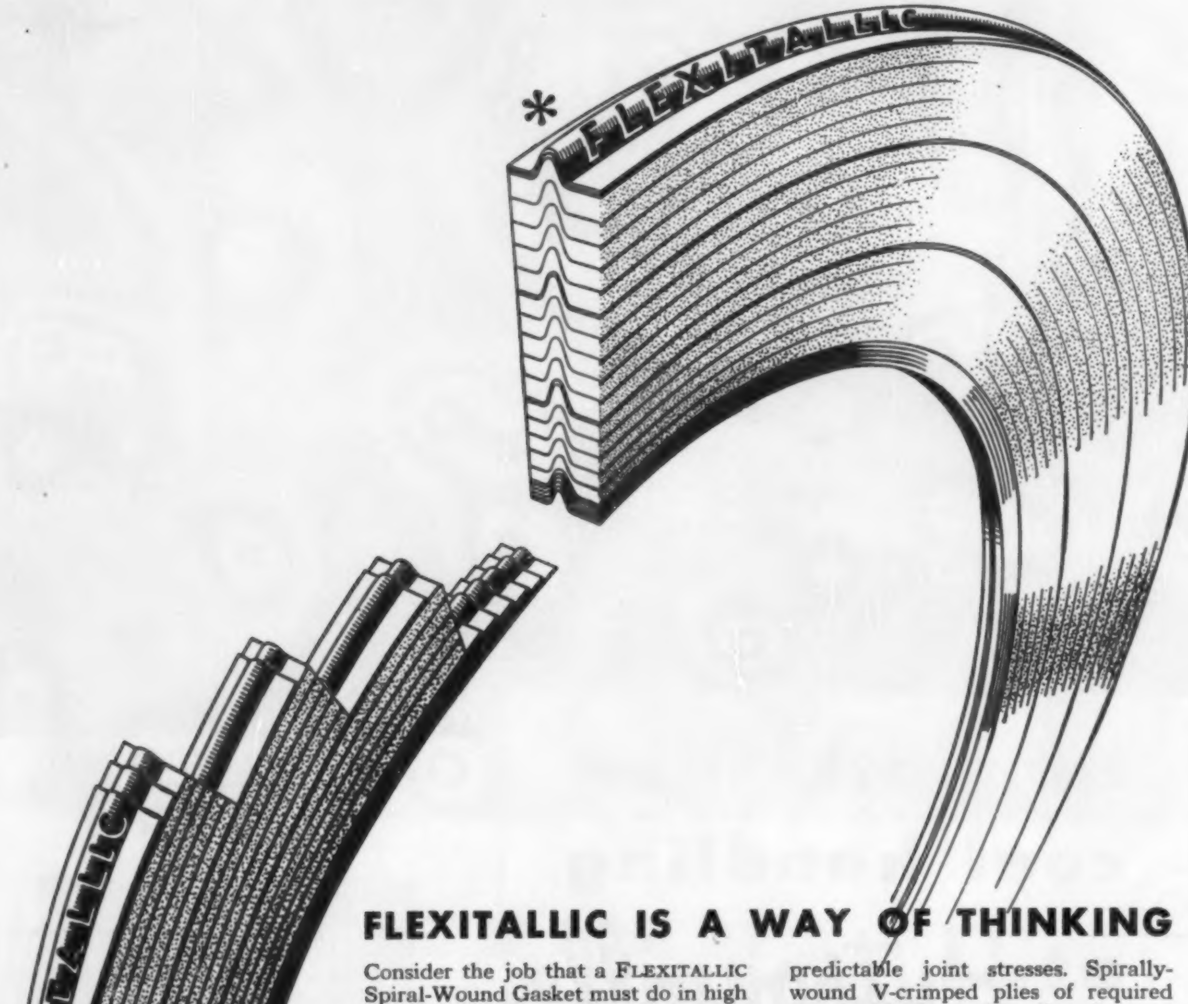
Water is your industry's most important raw material. Use it wisely.

Hall Laboratories, Inc.—Consultants on Procurement, Treatment, Use and Disposal of Industrial Water

Research-Cottrell's "double-deck" combination precipitators installed at Burlington Generating Station of Public Service Electric and Gas Company of New Jersey. At right, the simplified drawing shows the arrangement of the two integral mechanical-electrical collectors.



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COMBUSTION
Editorial

An Opportunity for Authors

There are many times during the course of an engineering career when one must make a choice among several economic alternatives. A familiar situation to many readers of this publication is to choose the most acceptable bid from among a group submitted for a specific type of power plant equipment.

Detailed specifications are one of the most familiar techniques used by prospective purchasers to have vendors submit bids on a common basis. For major components of central stations, these specifications may become documents comprising a hundred pages or more. In theory, at least, filling out such documents makes it possible to separate out the qualified and unqualified vendors. But when this has been done, the basic task of evaluating bids remains.

The literature on steam power plants is quite complete when it comes to descriptions of technical details and general economics of overall designs. Unfortunately this is not the case in the matter of economic evaluation of specific components, possibly because matters of purchasing policy may be involved in the many techniques developed by consulting engineers and other purchasers. And yet it may be asked, if an engineer develops an improved method for evaluating bids, why should it not become incorporated in the technical literature, as would normally be the case were he to make an improvement in engineering design?

In this issue of COMBUSTION we are pleased to publish the results of a comprehensive survey of dust collectors, with emphasis on analyzing proposals for this equipment, as carried out by M. J. Archbold of Commonwealth Edison Company of Chicago. We believe that our readers will find much information of value in Mr. Archbold's survey and are hopeful that its publication will stimulate engineers to reveal practices in evaluating other types of power plant equipment.

In a free competitive system evaluation of bids is a most essential process. While there are always intangibles to be considered, there are many areas of purchasing subject to concrete analysis. Any material that may be published to document techniques for evaluating bids may not only be helpful to engineers in similar positions of responsibility but will also strengthen the system that has meant so much to the economy of this nation.

Helping Those Who Help Themselves

Educating and developing young engineers and technicians has come in for considerable attention these days. As could be expected the expanding economy has virtually cleaned out the manpower reserves in these categories. Further the lure of immediate income from positions not demanding the discipline nor the training of the technician and the engineer has siphoned off a number of the possibly qualified among the young. The recent annual convention of the National Association of Power Engineers at Fort Worth, Texas reported on the results of that organization's decision to meet the problem head on.

The NAPE a year or so ago decided to sponsor in conjunction with the University of Wisconsin at relatively low cost to the beneficiaries a self-education program on steam plant operation. This program, aimed at developing power plant technicians, also enables them to successfully meet operating engineering license examinations. The response has been excellent. The NAPE reports about 2000 inquiries and, interestingly, an increase in its own membership of roughly 1000. They agreed at their recent convention to expand the program to include courses in mathematics, chemistry and physics at high school and college levels plus certain special refrigeration and air conditioning studies.

A report such as the above cannot fail to be inspiring. As a people it has been in our tradition to admire and encourage the efforts of any man who attempts to better himself. We accordingly salute the NAPE and its guiding officers for their vigorous approach to a nationwide problem and wish them every conceivable success.

*Dust Collectors for Central Station Steam Power Plants**

By M. J. ARCHBOLD

General Mechanical Engineer, Commonwealth Edison Company, Chicago, Illinois

For the past several years Pennsylvania State University has sponsored Electrostatic Precipitator Seminars, under the direction of Professor Ralph C. Armington, to which engineers have been invited from the chemical, cement, steel and electric utility industries, as well as from manufacturers of dust collecting equipment. These discussions have prompted some of the participants to make closer investigations of both purchasing and performance characteristics of their dust collecting equipment. This article, which is adapted from a paper presented at the 1956 Electrostatic Precipitator Seminar, is based on an intensive survey which the author made of practices on the Commonwealth Edison system. It brings together a great deal of specific information that central station design engineers may find of considerable benefit in specifying and analyzing proposals for dust collecting equipment.

THE first step in the survey of dust collecting equipment on the Commonwealth Edison system was to set up a table showing pertinent data from each collector in such form that comparisons could readily be made between installations. It was hoped that such a table would point up rather dramatically the criteria that produced the varying degrees of success which was obtained from such installations. It was also hoped that the efficiency performance could be tied directly to the equipment with convincing finality. That apparently is too much to expect at the present, due to the lack of proper test data on our own collector equipment. In spite of this, the table is a very excellent guide if the criteria can be properly evaluated.

Table I shows the comparative data. Since there were insufficient test data to be of much help in arriving at definite conclusions, all such data have been omitted from the tabulation. In the absence of such data, the next definite criterion is the appearance of the stack plume.

Collectors F, G and I regularly produce the best looking stack plumes. The gas velocity for Collectors F and G under actual operating conditions is 5.42 and 6.00 fps. For a pulverized coal slag tap furnace, this appears to be about the right velocity for high efficiency. Since I is a cyclone furnace with a much lower inlet dust loading, the velocity (8.15 fps) can be higher and still ob-

* Essentially complete text of a paper delivered at the Electrostatic Precipitator Seminar in June 1956 at Pennsylvania State University.

TABLE I—DUST COLLECTOR COMPARISON

	Boiler						Gas				Passages					Plate	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Collector	Capacity, × 1000 lb/hr	Pressure psig	Steam temp, F	Reheat temp, F	Firing*	Bottom†	Cfm, × 1000	Temp, F	Velocity, ft/sec	Treating Time, sec	No.	Width, in.	Heighth	Cross-Section Area, sq ft	Length, ft	Area, sq ft	Sq Ft Area/ 1000 Cfm
A	450	700	758	..	Pulv.	Dry	190	...	7.0	2.57	34	8	20	452	18	24,500	129
B	450	700	758	..	Pulv.	4—Dry 5 & 6—S.T.	190	360	7.14	1.68	38	8	17.5	443	12	15,960	84
C	500	1300	835	..	Pulv.	S.T.	270	365	8.77	2.05	44	8	17.5	513	18	27,720	102
D	500	1300	835	..	Pulv.	S.T.	270	365	8.77	2.05	44	8	17.5	513	18	27,720	102
E	1350	2100	1050	1050	Pulv.	Dry	657.7	305	8.22	1.64	100	8	20	1320	13.5	54,000	82.2
F	500	1325	935	..	Pulv.	S.T.	200	350	5.13	2.34	54	8	17.5	630	12	22,800	114
G	600	1325	955	..	Pulv.	S.T.	275	350	6.37	2.84	54	8	20	720	18	38,880	141
H	730	1900	1050	1000	Cyc.	S.T.	384	385	9.1	1.32	60	8	17.5	700	12	25,200	65.5
I	1100	1900	1050	1000	Cyc.	S.T.	546	334	8.15	2.2	84	8	20	1120	18	60,500	110
J	425	1325	935	..	Pulv.	S.T.	211	350	7.76	2.32	40	8	17	453	18	24,480	119
K	375	1275	910	..	Pulv.	S.T.	180	360	8.57	1.4	30	8	17.5	350	12	12,700	70.5
L	750	1325	935	..	Pulv.	S.T.	285	340	6.78	2.65	60	8	17.5	700	18	37,900	133
M	600	1325	935	..	Pulv.	S.T.	270	350	7.15	1.68	54	8	17.5	630	12	23,100	84.4
N	400	1325	910	..	Pulv.	S.T.	210	350	7.32	2.46	41	8	17.5	479	18	25,800	123
O	1320	1900	1050	1010	Cyc.	S.T.	567	303	8.7	1.84	72	8	18	864	16	41,472	73.1
P	1800	2100	1050	1050	Pulv.	Dry	780	287	6.95	2.59	68 (In) 60 (Out)	8 1/2 & 8	20	1813	18	92,160	118
Q	1108	650	755	..	6—Pulv.	6—S.T.	1450	340-350	6.32	2.53	300	8.5	18	...	16	172,800	119
	1030	..	...	..	1—Cyc.	1—Dry											
R	1450	2000	1050	1050	Pulv.	Dry	690	300	6.03	3.32	108	9	23.6	1903.5	20	101,520	147
S	2100	2000	1050	1000	Pulv.	Dry	1116	300	6.26	2.87	180 & 156	8.25 & 8	24	2970	18	148,600	134

* Pulv. = pulverized; Cyc. = cyclone. † S.T. = slag tap.

tain a good looking plume. The treating time, plate surface and wire per 1000 cfm of gas are all very good for Collector G. The amount of wire per bus section is on the high side and probably does account for lower efficiency at times when a few of the wires are dirty.

Column 9: Gas velocity is the first comparative item of significance, and it is very important. You will note that the velocities range from 5.13 to 9.1 fps. For a 98 per cent collector we are at present aiming at 6 fps.

Column 10: Treating time is a function of gas velocity and length of plate, and it varies from 1.32 to 3.32 seconds. For a 98 per cent collector, it probably should be in the order of 3 seconds.

Column 12: The clear space between plates has been quite uniform at 8 in., with only 3 installations greater than 8 in. Until more research has been done to justify a different spacing, we would tend toward the 8 in. now being used.

Column 13: Several years ago it was felt that 17.5 ft was about the maximum height which could be tolerated, but the size of boilers has increased so considerably that it has been necessary to increase the height of plates to hold the gas velocity down. As a result we have on order some plates 24 ft high. Since these have not yet been installed, it is not possible to make any comment. If care is taken in installing them so that they are relatively straight, no unusual difficulties are to be expected.

Column 15: The length of the plate in the direction of gas flow varies from 12 to 20 ft. For a 98 per cent collector, the plate length should certainly be 18 or more feet.

Column 17: The square feet of plate surface per 1000 cfm range from 65.5 to 147. Again we would think that 145 to 150 is a reasonable figure for a 98 per cent collector on pulverized coal furnaces.

Column 19: Bus sections per 100,000 cfm ranges from 0.62 to 2.86. Certainly 0.62 is far too low, but whether we should aim at 3 to 4, as is the practice of the Consolidated Edison Company of New York, is problematical.

Column 20: Square feet of plate surface per bus section range from 3990 to 11,520. In the future, it will be our aim to be below 10,000, possibly 8000 or lower, and if disconnects can be arranged at reasonable cost, possibly this figure can be cut in two to take care of short circuits.

Column 22: Spacing of wire ranges from 5 to 9 in. with most of them in the 6 to 7 in. range, which appears about right.

Column 23: The length of high tension wire per bus section, varies from 2887 to 10,625 ft. Here again the right amount is probably somewhere between 5000 and 8000 ft.

Column 24: The amount of high tension wire per 1000 cfm of gas varies from 44 to 125 ft. It would seem that this item should be more definite. For a 98 per cent collector, we probably should aim at close to 150 ft of wire per 1000 cfm.

Column 31: The length of rapping cycle should be short. The length of time between raps of an individual rapper certainly should not exceed 60 seconds. It will be noted that one collector raps on a 6-minute cycle and that is much too long, since the individual raps are quite noticeable in the stack plume.

Column 32: The percentage of plate rapped must definitely be held low; 25 per cent is much too high. The percentage should probably be in order of 6.25 per cent or lower and the rapping sequence should be synchronized to prevent overlapping.

Columns 33 to 36: We can offer very little with reference to wire rappers, due to our limited experience. Precipitator N is equipped with M-I rappers and they are ineffective. H and I have vibrolators, and an inspection of I showed heavy deposits on the wires. E has syntrons and these are apparently heavy enough to do the job and, when properly adjusted, have kept the wires free from doughnuts.

Selection of a Dust Collector

The first important item is to determine the maximum amount of dust that will be allowed to escape from the stack. If pulverized coal is to be burned in a dry bottom furnace, the amount of dust that could pass into the

TABLE IA—DUST COLLECTOR COMPARISON

	Bus Section			Wire					Type			Plate Rappers				Wire Rappers			
	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Collector	No.	Section/100,000 Cfm	Sq Ft Plate/Section	Quantity, ft	Spacing, in.	Ft/Bus Section	Ft/1000, Cfm	Efficiency, % Guaranteed	Collector	Rectifier	Wave	Type	Number	Length of Cycle, sec	Rapped at One Time, %	Type	No.	Length of Cycle, sec	Rapped at One Time, %
A	4	2.1	6,125	16,350	9	4,087	86	95	Elec.	...	...	M-I	16	..	6.25	...	4		
B	4	2.1	3,990	...	...	...	...	90	Elec.	Mech.	Half	Motor	4	..	25	...	0		
C	6	2.22	4,620	24,640	5.25	4,107	91	92.5	Elec.	Mech.	Half	M-I	8	30	12.5	...	0		
D	6	2.22	4,620	24,640	5.25	4,107	91	92.5	Elec.	Mech.	Half	M-I	8	30	12.5	...	0		
E	12	1.83	4,500	...	...	...	...	97	Comb.	Elec.	Half	M-I	..	..	...	Syn.	..		
F	4	2.0	5,700	18,900	6	4,725	94.5	92	Elec.	Mech.	Half	Motor	4	60	25	...	0		
G	4	1.45	9,720	34,560	5	8,640	125	95	Elec.	Elec.	Half	M-I	16	60	6.25	...	0		
H	4	1.04	6,300	21,000	6	5,250	54.6	80	Elec.	Mech.	Half	...	..	..	...	Vib.	16		
I	8	1.46	7,560	53,760	8	6,720	98.5	90	Elec.	Elec.	Half	M-I	12	30	8.3	Vib.	..		
J	4	1.9	6,300	16,300	7	4,075	77.3	95	Elec.	Mech.	Half	M-I	4	10	25	...	0		
K	4	2.22	3,175	11,550	7	2,887	64.2	90	Elec.	Mech.	Half	Pneu.	4	90	25	...	0		
L	4	1.4	9,475	23,100	...	5,775	81	90	Elec.	Mech.	Half	M-I	4	12	25	...	0		
M	4	1.48	5,700	18,900	7	4,725	70	90	Elec.	Mech.	Half	Pneu.	8	..	12.5	...	0		
N	6	2.86	4,300	21,500	6	3,583	102	95	Elec.	Mech.	Half	M-I	24	60	4.17	M-I	6		
O	6	1.06	6,912	33,200	...	5,533	58.5	90	Elec.	Mech.	Full	Pneu.	12	360	8.33	...	..		
P	8	1.026	11,520	85,000	...	10,625	109	97	Elec.	Elec.	Half	M-I	16	..	12.5	...	8		
Q	24	1.66	7,200	124,800	9	5,200	86	95	Elec.	Mech.	Full	E-M	240	..	...	Pneu.	72		
R	20	2.9	5,076	60,912	6 & 12	3,045	88	98	Elec.	Elec.	Half	M-I	64	..	1.56	Vib.	32		
S	18	1.62	8,260	136,000	6	7,550	122	98	Elec.	Elec.	Half	M-I	36	..	2.78	M-I	36		2.78

inlet of the collector might be in the order of 6000 grains per 1000 cu ft of gas at standard conditions. If a 98 per cent collector is to be purchased, it would permit 120 grains per 1000 cu ft of gas to escape.

If a pulverized coal wet bottom furnace is to be purchased, the dust loading might possibly be in the order of 4000 grains per 1000 cu ft. To obtain a maximum dust loading of 120 grains per 1000 cu ft, which is equivalent to that of a dry bottom furnace, a 97 per cent collector is indicated.

For a furnace equipped with cyclone-type burners and a wet bottom, the dust loading should be under 1000 grains so that an 88 per cent dust collector could be selected. However, the dust from this type of burner will have a high percentage of very finely divided particles that may be quite dark in color compared with the very light gray of the pulverized coal furnace. From an appearance standpoint it would probably be desirable to step up the efficiency a few per cent, say to 90.

In reviewing the specifications for dust collectors purchased in 1943, it was noted that the consulting engineers requested a breakdown of prices and weights and certain data relative to dimensions. The thickness of metal in the housing and supports was well delineated, but pertinent data, so important in determining the ability of the collector to perform properly, were omitted. This was largely because the consultant and the purchaser did not understand the importance of obtaining such data. Gas velocity was about the only important design information requested. This was equivalent to sending a specification to automobile manufacturers stating that the car must be capable of operating at, say, 65 mph. It is hardly likely that any purchasing department, which normally selects the lowest bidder, would purchase a Cadillac or Packard, when a Ford, Plymouth or Chevrolet could be purchased for far less, and still meet the speed requirement.

Since that time specifications have been improving. Besides asking for the price and terms that formerly had been requested, information is now being obtained that will permit a more intelligent comparison of the collectors and will go far in permitting the engineers to put evaluations on performance. In so doing, it may be found that the lowest bid might not be the most economical purchase to make.

Table II lists the pertinent data which should be requested for making a proper evaluation.

TABLE II—PERFORMANCE

(Based on using ——————— coal)

A. Boiler steam output (lb/hr)	1,000,000	2,100,000	Maximum
B. Flue gas quantity (cfm)	560,000	1,116,000	1,248,000
C. Temperature of gas (F)	270	300	305
D. Draft loss through collector, including perforated plates if used (in. water)			
E. Velocity of gases through collector passages (ft/sec)			
F. Gas contact time (actual time opposite plates) (sec)			
G. Guaranteed residual concentration at collector outlet with dust concentration at collector inlet of 6.25 gr/cu ft at 1 atmosphere and 32 F		(98% eff.) 0.125	
H. Expected (but not guaranteed) residual concentration at collector outlet with dust concentration at collector inlet of 6.25 gr/cu ft at 1 atmosphere and 32 F.			
I. Collecting plates			
a. Height of plate		ft	
b. Length of plate in contact with gas		ft	
c. Distance between plates (C to C)		in.	
d. Thickness of plates		in.	
e. Clear space between plates		in.	
f. Number of plates			
g. Number of passages			
h. Cross-sectional area of passages		sq ft	
i. Area of plates (total)		sq ft	
j. Ratio of plate to gas quantity		sq ft/1000 cfm	
k. Ratio of plate to bus section		sq ft/bus section	
J. High tension wires			
a. Spacing of wires in direction of gas flow		in.	
b. Length of wires (total)		ft	
c. Ratio of wire to gas quantity		ft/1000 cfm	
d. Ratio of wire to bus section		ft/bus section	
K. Electrode plate rapping equipment			
a. Make			
b. Type			
c. Quantity			
d. Percentage of plate rapped by each rapper		%	
e. Time interval between raps of the same rapper		sec	
f. Total rapping time for one complete rapping cycle		sec	
g. Weight each		lb	
h. Rapping force, each		ft-lb	
i. Price for each additional rapper			
L. High tension wire rapping equipment			
a. Make			
b. Type			
c. Quantity			
d. Percentage of wire rapped by each rapper		%	
e. Time interval between raps of the same rapper		sec	
f. Total rapping time for one complete rapping cycle		sec	
g. Weight, each		lb	
h. Rapping force, each		ft-lb	
i. Price for each additional rapper			
M. Number of hours collector can run at specified cfm and inlet loading of 6.25 gr/cu ft without emptying any hopper			
N. Total hopper storage capacity of collector (tons of fly ash based on 50 lb/cu ft)			
O. Rectifier tubes (electronic system)			
a. Number (compl. install.)			
b. Replacement price, each			
c. Guaranteed life, each			
d. Expected life			
e. Capacity, each			
f. Physical size, in., each			
g. Are sockets on anti-vibration mounting?			
P. Selenium rectifiers			
a. Number of units (total)			
b. Replacement price (per unit)			
c. Guaranteed life			
d. Expected life			
e. Rating of unit			
f. Physical size per unit			
Q. Power required at 3 phase 60 cycle, 440 volt (kva)			
R. Power factor (%)			
S. Transformer			
a. Make			
b. Type			
c. Rating (kva)			
d. Quantity			
T. Tap changing equipment			
a. Make			
b. Type			
c. Number of taps			
d. Tap voltages (volts)			
V. Bus sections			
a. Number			
b. Number of sections lost if one transformer is out of service			
c. Ratio of bus sections to gas quantity		sections/100,000 cfm	
d. Number of electrical sections in series			
e. Number of electrical sections in parallel			
f. High tension voltage (peak)		volts	
g. High tension voltage (rms)		volts	
h. Current density on wires		ma/ft	
i. Total power on high tension electrodes		kw	
j. Ratio of power on H.T. electrodes to gas quantity		watts/1000 cfm	
W. Type, number, and make of rectifier sets			
X. Half or full wave rectification			
Y. High tension disconnecting switches			
a. Make			
b. Type			
c. Rating			
d. Quantity			
Z. Collector shell and hoppers			
a. Thickness of steel plate of shell			
b. Thickness of steel plate of hoppers			

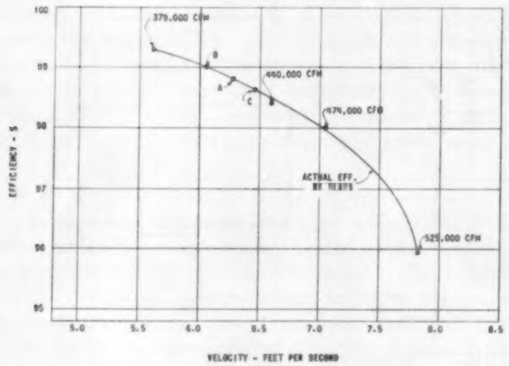


Fig. 1—Relationship of gas velocity to collector efficiency

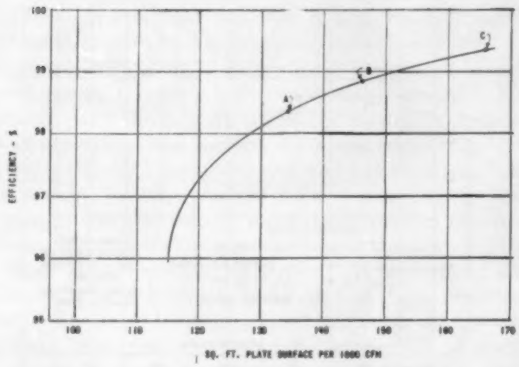


Fig. 2—Relationship of plate surface to collector efficiency

After the data from the bids are tabulated, and rather wide differences are noted, the user may be confused as to the relative importance of some of the information and may wish to try to evaluate it.

Some of the pertinent data from three bids have been listed to be used as an example and are shown in Table III. Since all three bidders have guaranteed 98 per cent, the one with the lowest offering could be selected without further consideration. On the other hand, it is quite obvious from the difference that certain evaluations should be made, since one of these collectors will definitely perform better than the rest.

TABLE III—PERFORMANCE COMPARISON

Bidder	Desired Bogie	A	B	C
A. Efficiency		98	98	98
B. Gas velocity		6.26	6.07	6.45
C. Plate surface (sq. ft/1000 cfm)		134	147	166
D. Bus sections		18	24	24
E. Bus sections/100,000 cfm		1.62	2.16	2.16
F. Sq ft plate/bus section		8600	6800	7700
G. Spacing of wire (in.), direction gas flow		6	7	6.5
H. Ft wire/100 cfm		122	177	138
I. Plate rappers		36	144	168
J. Wire rappers		36	48	72
K. Rapping intensity (ft-lb)		25	0–12	11
L. Length of plate in direction of gas travel		18	20	24
M. Gas contact time (sec)		2.87	3.30	3.72
N. Power input (kw a-c)		360	270	240
O. Wire type and material				
P. Railing type and size				
Q. Access doors				
R. Cost/sq ft plate				
S. Adjusted cost/sq ft plate				
T. Cost/lb				
U. Adjusted cost/lb				
V. Adjusted total				

Gas Velocity

Fig. 1 has been prepared from an actual test, and with a fuel quite similar to that which will be used in our new equipment. In operation of steam-generating equipment the quantity of flue gas will vary from the optimum quite a little. The design may call for 10 to 20 per cent excess air but it is not unusual to find the excess much higher, due either to leaks in the casings and ducts, or to wear on the air heater seals, or to the operating force, purposely boosting the percentage to reduce furnace slagging difficulties. Irrespective of the reason, it will be very desirable to have a collector whose operating efficiency is as high on the curve as possible and not down close to the knee. In this instance Collector B should provide 0.4 per cent higher efficiency than Collector C.

Plate Surface

Fig. 2 shows the relationship of plate surface to gas quantity. If this curve has the correct shape, then Collector C should have nearly a 1.0 per cent advantage over Collector A, which in turn is getting rather uncomfortably close to the bend of the curve. Any sizable increase in excess air or leakage, could put Collector A below the desired 98 per cent efficiency.

Length of Plate in Direction of Gas Travel

Fig. 3 has been developed from empirical formulas and shows the relationship of the length of plate and gas velocity, in relation to efficiency. Here again Collector C has a considerable edge over Collector A.

Two additional curves should be developed as aids in making the selection. One such curve should be the "feet of high tension wire" plotted against "collector efficiency" and the other would be the "power on the electrodes, per 1000 cfm of gas," plotted against "collector efficiency." Neither of these has been developed, but we do have test data which have been put in curve form and which show the improvement resulting from increasing the power input to mechanical rectifiers. This is shown on Fig. 4, while Fig. 5 shows the manner in which this collector is connected electrically and helps to explain Fig. 4. Referring to the curves on Fig. 4, it will be noted that Curve I was produced by applying 15 kva to all 3 rectifiers. By increasing the power from 15 kva to 25 on A or inlet rectifier, the performance as shown by Curve II was improved tremendously at the higher gas velocities. By pushing all 3 rectifiers up to 25 kva, Curve III shows still greater improvement. This is rather a dramatic portrayal of what effect increased

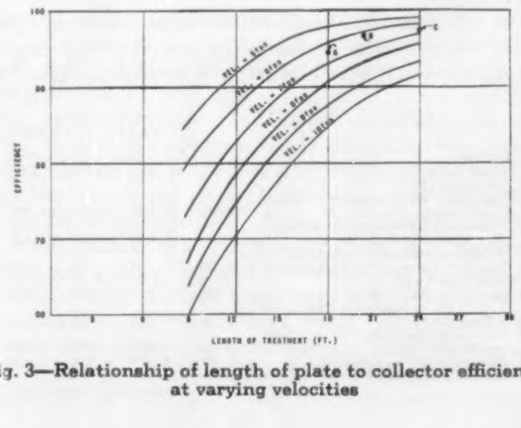


Fig. 3—Relationship of length of plate to collector efficiency at varying velocities

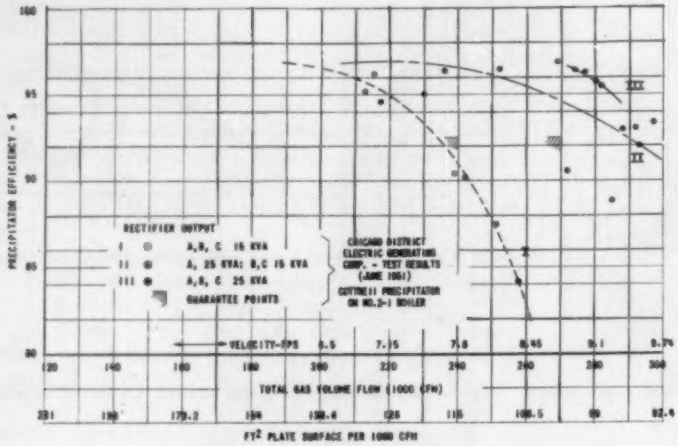


Fig. 4—Precipitator efficiency

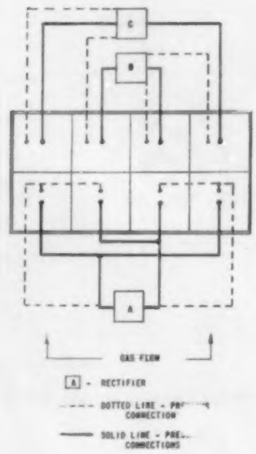


Fig. 5—Electrical connections

power on the collector will accomplish. It is unfortunate that the power on the high tension bus was not measured, as it would be a very valuable bit of information for selection of collectors.

Referring again to Fig. 5, it will be noted that the inlet shows dotted lines. The left half wave connection of the rectifier was connected to the two left bus sections, and the right half wave was similarly connected to the two right-hand sections. Since the resistivity of the dust varies with temperature and since the air-leakage appears to lower the gas temperature more along the outside walls, it was considered best to reconnect all rectifiers so that the outside sections could be controlled separately from the inside sections. The same idea was carried out on the outlet sections. This is reported to have made a definite improvement.

By this time the engineer may have a fair idea regarding the collector which he may feel should be purchased. He should take another step, before making a final conclusion.

Table IV was prepared to compare the proposals of four bidders. Most of the figures pertaining to the dollars bid have been deleted for obvious reasons. The base bid was on a 98 per cent combination, mechanical-electrostatic dust collector, whereas Alternate No. 1 covered a straight 98 per cent electrostatic collector. Since this was our first attempt at a comprehensive collector evaluation it may have much in it that can be criticized.

In this instance, the evaluation of transformer equipment Item 4, was estimated by the electrical department, whereas it would be better to request prices on this equipment from the manufacturer. This same comment goes for Item 5.

Item 7 covers power to plates and may be considered rather unfair since the customer should welcome as much power on the plates as the collector will take, and not penalize the manufacturer for doing a good job. The outstanding comparison is shown in Items 11 and 12. Although the combination collector was lowest in price yet this evaluation very definitely, and with a wide margin, threw it over to the straight electrostatic.

Other items could and should be evaluated and were not in this particular instance. If the dust collector is to be located out of doors, then the protection against weather and corrosion is an important factor. For high-sulfur coals, a metal cap or housing over the top of the collector is a very valuable asset and should be evaluated. Two other items of tremendous importance are the square feet of plate surface, and the total length of wire. These should definitely be thrown into the picture and evaluated so that the manufacturer who is trying to give you a good job is not unduly penalized. In one instance, the low bidder was quite low on plate surface and high tension wire. By increasing the height of the plates 3.5 ft, his plate surface and total wire were better than his competitors, and this additional gas passage area reduced the velocity from 7.1 to 6.03 fps.

As will be seen from the curves on Fig. 1, this reduction in velocity is equal to an improvement of roughly one per cent in efficiency over what would otherwise have been obtained, and this has been achieved at relatively little increase in cost.

Acceptance tests are usually conducted under ideal

TABLE IV—ANALYSIS OF DUST COLLECTORS

1. Scheme	Base				Alternate No. I				Alternate No. II				
2. Manufacture	A	B	C	D	A	B	C	D	A		B	C	D
3. Total cost ($)									I	IA			
4. Deduction for evaluation of transformer equip. over base ($)	44,000	30,000	Base	84,000	Base	46,000	16,000	112,000	96,000	44,000	60,000	Base	84,000
5. Deduction for evaluation of rapping equip. over base ($)	Base	3,600	9,600	23,400	Base	14,400	28,800	23,700	2,400	Base	9,600	10,200	20,400
6. Total cost minus deductions ($)													
7. Power to plates (kw)	90	89	65	96	134	145	190	210	136	115	130	78	96
8. Draft loss (in H_2O)	3.03	3.15	3.30	3.40	0.30	0.30	0.35	0.4	2.81	2.9	3.2	3.2	3.4
9. Fan power due to draft loss (kw)	364	378	396	408	36	36	42	48	337	348	384	384	408
10. Total gain in capability compared to base (kw)	60	47	53	10	344	333	282	256	41	51	Base	52	10
11. Savings in operating cost over base capitalized ($)	9,000	7,050	7,950	1,500	51,600	49,950	42,300	38,400	6,150	7,650	Base	7,800	1,500
12. Capability savings over base ($)	7,500	5,875	6,625	1,250	43,000	41,625	35,250	32,000	5,125	6,375	Base	6,500	1,250
13. Net total cost ($)													
	98% Mechanical-electrostatic				98% Electrostatic				99% Mechanical-electrostatic				

conditions, with the collector in a very clean condition and with the power at the optimum level, and the excess air carefully controlled. The curves in this report reflect those conditions, whereas in all probability, daily operating efficiencies after the equipment attains a slight age, may be 3 to 5 per cent less than obtained on test.

Roof

For indoor dust collectors, it is not so important that the roof be watertight, but for an outdoor dust collector a tight roof is definitely of the first order. Observations of outdoor dust collectors where leaks had occurred show that a small amount of moisture produces semi-hard lumps that often bridge the gas passage. The lumps are sufficiently hard to remain in one piece, even after falling a distance of 18 to 20 ft. The sections in which these occur are either out of service until these can be removed or the efficiency is too low to be tolerated. Many times these lumps cannot be dislodged until the boiler can be taken out of service.

On several outdoor dust collectors gunite had been applied to the inside of the shell to protect it from corrosion. Either due to faulty workmanship or to the fact that no gunite can be expected to be monolithic without flaws, cracks developed, permitting gas to reach the steel shell where the sulfuric acid condensed on the plates corroding them through in a number of places.

To correct this situation, the gunite was removed from the inside and insulating material that had been waterproofed with "Insulcote" had been applied to the outside. Over the roof a welded air-right metal cap had been placed, with sufficient head room to permit maintenance of the electrical equipment and to make the necessary repairs to the collector plates, wires, etc. The fact that these collectors were on the discharge side of the induced draft fans, made it necessary to install small blowers to create a positive pressure in this area so that gas would not leak out in this chamber. This housing has not been insulated and after several years service it still shows no signs of corrosion.

The roof originally had been covered with a lightweight concrete aggregate which was then coated with a bitumastic sealing compound. This material has a considerable tendency to crack with changes in temperature and expansion so that moisture does reach the plate and chill it, causing the sulfuric acid in the gas to condense out and corrode the inside of the collector. On a recently installed collector, an effort is being made to correct this condition by imbedding a glass cloth membrane in the bitumastic waterproofing so that any cracks which do occur will remain tight against the weather. At this installation all projections above the roof will be flashed similar to the flashing used in the roofing trade.

From these experiences, it is rapidly becoming an accepted belief that a welded air-tight metal cap that has a minimum of openings through it and in which the air infiltration can be properly controlled, will prove to be the most practical and most economical installation in the long run.

Voltage Regulators

Until quite recently, little attention has been given the matter of voltage regulation. When the manufacturers first proposed automatic voltage regulation, the price, which was then roughly $1000 per rectifier, was a very large obstacle. No one was then in a position to justify their purchase.

Subsequently, visits to the stations pinpointed several very important facts relative to voltage control. For the most part, the adjustment of the voltage is done by the electrician. The cabinet or room containing this control is usually kept under lock and key because of the high voltage involved, and the electrician carries the key. This control is also usually located adjacent to the dust collector which is on the opposite side of station from the center of activity of the electrician. A trip out of the rectifier can be and usually is signaled to the boiler room panel. The operator then calls the electrician, and in due time, depending upon where he happens to be working on the property, he arrives to put the rectifier back in service. In the larger stations where distances are great this can mean a material outage time. The tendency is to set this control low enough so that the collector will operate over a wide range of temperature and gas velocity, and over a wide range of dust characteristics without tripping out. If reference is now made to Fig. 4, it can be readily seen that under certain conditions, a small variation in power to the collector can make wide variations in collector performance.

Armed with this information, it was not difficult to convince ourselves that voltage regulators might be a necessity if we were to maintain clear stacks and keep down complaints. The last two collectors have been purchased with voltage regulators, but they are not yet in service, so we cannot comment on their effectiveness.

In addition to this, voltage dividers are being supplied in the rectifier cabinets together with the necessary voltmeters and ammeters to determine accurately the voltage and power being applied to the high tension electrodes.

If it proves possible to obtain a series of efficiency tests at various loads on this equipment, the following curves may then be established:

(*a*) Watts per thousand cfm of gas plotted against efficiency.
(*b*) Voltage plotted against efficiency.
(*c*) Amperes per ft of wire versus efficiency.
(*d*) Feet of wire per thousand cu ft of gas versus efficiency.

Rappers

Maintaining a commercially clean dust collector is of paramount importance in obtaining good collector efficiency. For this reason, the type and number of rappers becomes significantly important. The old concrete plates had chain scrapers that removed the dust but which were difficult to keep in operation. These have all been replaced.

The swinging-hammer rapper is still installed on several of the older dust collectors. It is quite effective in dislodging the dust from the plates, but the re-entrainment is quite heavy, and the stack plume is darkened materially during the rapping period. They are motor driven and are automatically timed to complete a cycle in approximately one minute, but due to re-entrainment, none are operated during daylight hours. Some of the objectionable darkening of the stack plume is due to the large amount of plate surface rapped at one time. For comparison one installation has four of these which means that 25 per cent is rapped at one time, whereas the collec-

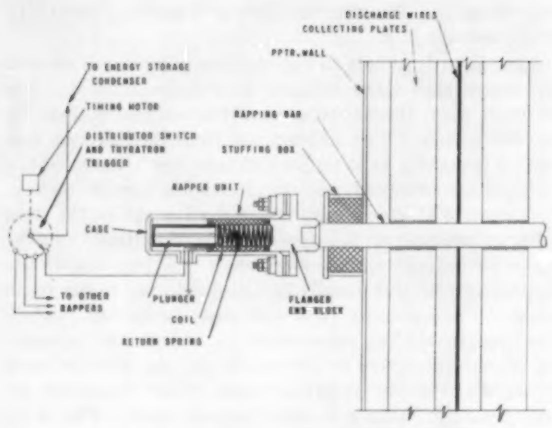


Fig. 6—Magnetic-impulse rapper

tor adjacent, which is not much larger, makes use of 16 magnetic impulse rappers, so that only 6.25 per cent is rapped at one time.

To get just enough rapping to dislodge the dust, but not enough to create excessive re-entrainment, requires facilities for obtaining micrometer adjustment of the rapping intensity. The swinging-hammer rapper does not have this feature.

Pneumatic rappers are used on several dust collectors on the system. These have various types of actuating devices. Most of these can be set up to deliver a sufficient rap to dislodge the dust. They use air, so that if many rappers are involved, their frequent use usually cannot be tolerated because it drags the air pressure too low. With a longer interval of timing, they also cloud the stack.

On one installation where they are pneumatically timed, several rap nearly simultaneously so that a clouded plume is produced. This rapper has not been received with much enthusiasm.

The magnetic-impulse rapper is now installed on more collectors than any other type and has been able to overcome many objections mentioned above. It is possible to alter the frequency of rapping as well as the intensity, so that it is difficult to tell by the appearance of the stack when they are shut off. Fig. 6 shows the magnetic-impulse rapper.

During the first few years of operation of this rapper, the operating people felt that it was nearly perfect and were quite vocal in their praise of it. With further experience, however, certain failures began occurring.

The induction coil is mounted on a Bakelite sleeve and this is firmly held in the rapper housing which in turn is attached to the rapper bar. Each rap imparts a shock to the winding insulation. A number of these coils have broken down at the turns. Others have broken down at the joint where the leads are connected to the coil.

Rectifiers

Until the electronic tube had proved its longer life, it was our opinion that the mechanical rectifier was the more economical of the two. It still is on one of our small stations where the regular electrician maintains the mechanical sets along with his normal duties. In the larger stations, where there are a number of dust collectors and where there are a large number of rectifiers on each collector, the time required just to keep these rectifiers clean runs into considerable money. At one station, there are 12 mechanical rectifiers which require weekly cleaning with a weak solution of ammonia to neutralize the nitrous oxide deposits. This requires 20 man-hours of labor. You can see that, were the next collector equipped with mechanical rectifiers, it would take the full time of one man just to keep them clean, and repair costs would be on top of this item.

Inspections of Dust Collectors

To determine accurately the conditions under which the precipitator is working, care must be exercised in shutting the equipment down so that dust deposits will not be disturbed.

Observance of these deposits will shed considerable light on just why the precipitator does a good or poor job. In order to make quick repairs to the steam-generating equipment, it is frequently the practice to open all access doors and run the fans at top speed. With the boiler cooled in this fashion, the inspector can hardly expect to find the deposits undisturbed. The high air velocities will have destroyed much of the evidence he is seeking.

To make the inspection, proper equipment should be used. A good boiler inspector's suit is almost a necessity. Such a suit usually will have an undergarment. Both garments will have rubber bands at the wrists and ankles to keep the dust out at these points. The outer garment will be equipped with a hood which also will have a rubber band to keep the hood snuggly against the face. A snug-fitting skull cap should be employed under the hood. In addition to this, a good set of goggles and a dust mask are a necessity as well as a good pair of gloves, especially if the precipitator is hot. A sealed-in beam searchlight will aid greatly in taking a good look. This sounds very elementary, but the fact that very few power plant men supply themselves with adequate inspection equipment, probably accounts for many of the poor conditions that exist.

Fig. 7 shows roughly a cross-section through one of our

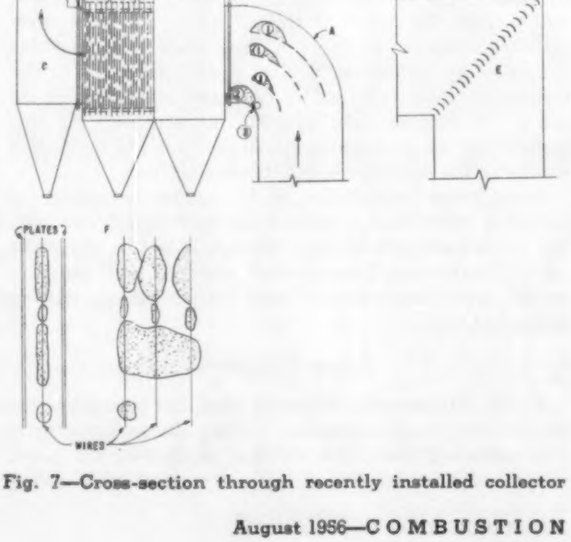


Fig. 7—Cross-section through recently installed collector

new collectors. The dust builds up on the vanes of elbow "A" as indicated by the figure "1." It also builds up at "2" to a depth of approximately 4 ft just ahead of the perforated plate "B."

The buildup at "2" is now being removed daily by air jets located in a header as shown at "3." This buildup, must have materially altered the uniform flow of gas through the collector, and must have had a detrimental effect on the collector efficiency. The direction of blowing is in the direction of gas travel, and this is correct in so far as dust removal is concerned. However, from the standpoint of gas distribution through the collector, it is not good. It would have created less disturbance when blowing, had it been placed immediately below the perforated plate and the nozzles pointed in the opposite direction. No solution has been found for the deposits on the turning vanes at "1." The elbow "A" is directly above a tubular air heater, which is an excellent device for straightening out turbulent gas. Had this elbow been made square, as indicated by "E," and had small multiple-turning vanes with inlet and outlet edges tangent to the gas flow been mounted as indicated across the corner, dust probably could not have built up sufficiently to have upset the flow pattern through the heater. If dust should build up on them, then it might be necessary to resort to the soot-blowing technique, or to syntron vibrators to remove it. The spacing of these vanes is customarily the distance of $^1/_2$ the chord.

Inspection of the perforated plate "D" showed all holes completely plugged from the top down to the midpoint of the plate, and nearly half of its width. This must also have had a very detrimental effect on gas distribution. The wires on this collector were being rapped regularly, but after five months operation, the buildup in certain sections was sufficient to bridge from wire to wire and to be several inches thick. Some of it was

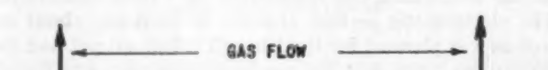


Fig. 8—Rectifier arrangement for collector in Fig. 7

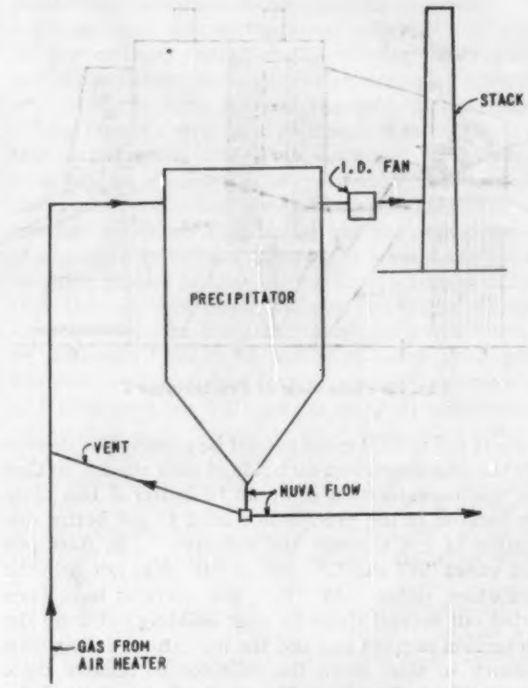


Fig. 9—Dust collection system for collector in Fig. 7

smooth as though trowelled. This condition is illustrated at "F." It will be noted that there are no turning vanes in the outlet elbow. This is probably the only collector on the system where such vanes have been omitted. At this time we are not certain whether it was a good idea to leave them out. It is possible that turning vanes at this point would tend to maintain a more uniform gas flow through the precipitator.

Fig. 8 illustrates the six full-wave rectifiers connected to the six bus sections of this same collector. Whereas this collector met its guarantee when tested, which indicated that full-wave rectification may be efficient, yet our thinking now is that half wave rectifiers would have provided twice the number of bus sections and we could have had two in series as well as six in parallel. Since there is rarely a time that one or more sections are not in trouble and rarely are they all in at one time, it is now believed that the half-wave arrangement would have given us improved overall collection. When one section is out of service 16.6 per cent of the gas escapes untreated, whereas with half-wave rectification, the remaining section in that series could be expected to pick up possibly 70 per cent of the dust in that lane instead of losing 100 per cent of it.

Fig. 9 shows the schematic layout of the dust collection system in connection with the collector shown in Fig. 7. Three of our precipitators are equipped with the air-slide type of ash conveyor and all three vent back into the inlet of the precipitator. Tests on the dust loadings in the vent show an unusually high concentration of ash. This particular collector, venting back to the inlet, circulates nearly 50 per cent of the normal collection. This was an item that was completely overlooked in the design.

Fig. 10 shows a side view of Precipitator F. The perforated plate "A" in this instance is at the air heater outlet, rather than at the precipitator inlet. Wind tunnel

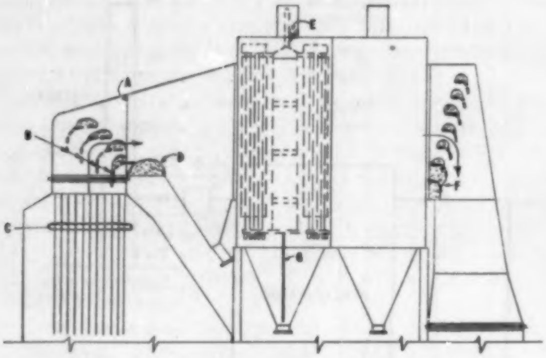


Fig. 10—Side view of Precipitator F

engineers tell us that gases cannot be expected to diverge more than six degrees on each side of their stream, so that from this consideration it would be better if this plate were located at the precipitator inlet to get better distribution of gas through the collector. The dust pile up on vanes "*B*" and "*F*" and at "*D*" does not help the distribution either. At "E," bus sections have been shorted out several times by dust building out from the high tension support rod and the insulator. It has been necessary to shut down the collector to remove these shorts. The buildup at "*F*" completely blocked off the perforated plate for the entire width of the collector. The baffles at "*G*" were badly corroded on the tops, so that much of the gas could bypass the collector. Fig. 11 is of an identical boiler layout and shows the dust buildup on the turning vanes of the inlet elbow above the air heater. The shape of the deposit shows there is some laning, possibly due to the slugging of some air heater tubes, or it may be due to the damper setting. The superheater and economizer gas passes are parallel and both are dampered at the entrance to the air heater. At certain loads the economizer damper is nearly closed, forcing all the gas through the superheater side. The temperature of the gases under such conditions will vary more than 100 deg F from one side to the other.

To dislodge the dust from the turning vanes, an experiment is to be tried out. The right half of this collector is to have the turning vanes divided horizontally into three sections. Following the rule of thumb of wind tunnel engineers, these vanes will be small semi-circles, with the inlet and outlet edges extended only far enough to be tangent to the gas flow. They will be spaced apart just half the length of their chord. One section will be rigid. It is the hope of the designer that it will automatically keep itself clean, which is probably too much to hope for. The middle or second section will be spring mounted and will have a heavy-duty syntron vibrator to shake off the dust. The third section will have the vanes pivoted so they can be rotated rapidly against a stop. It is hoped that this will jar the dust loose and that the pivots will not freeze tight in their bearings.

To show what can sometimes be accomplished with a poor layout, Fig. 12 is shown. "*A*" of this sketch shows the plan view of "*C*" precipitator as it was originally installed, and "*B*" shows the design after rebuilding. "*A*" shows two sections in parallel and three in series. The gas velocity was very high and the efficiency was very poor. This collector was rebuilt according to Fig. 12. Here we have four sections in parallel and two in series. The former idea of having three in series was very good, except for the fact that the velocity was very much too high. A sacrifice was made by building the new collector with two in series; but by having four in parallel instead of two, the gas velocity was dropped to one-half the former velocity and that more than offset the loss due to the triple series arrangement, and the collector now meets its guarantee.

Fig. 13 shows a cross section of the combination mechanical electrostatic Collector E. It was and still is thought by some of our engineers and the engineers of our consultants, that to obtain the highest collection efficiency, a combination collector should be used. To collect the high-resistance ash of the low-sulfur eastern coals, such a belief may be true. To collect the ash of the high-sulfur coals of Central Illinois it is not necessary to have both a mechanical and an electrostatic collector in series.

It appears at this time to be an unfortunate installation. The collector has been in service about six months, during which time two inspections have been made of it. The electrostatic section appears to be doing about as well as was planned for it, although it has not yet had its acceptance tests, but the mechanical section was found badly plugged during the first inspection. The draft loss through it had nearly doubled. It was not surprising to find this condition since the drying out and starting period had been done by using relatively large quantities of natural gas and the stack temperatures were low.

When starting the second run, a conscientious effort was made to have the flue gas hot and as dry as possible during the start and regular operation. The stack temperature could run at 275 F, but the incoming air to the

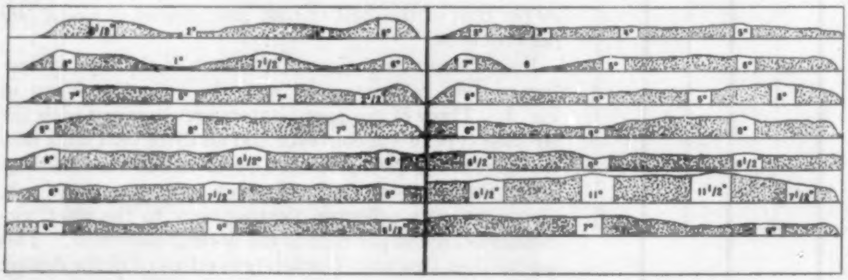
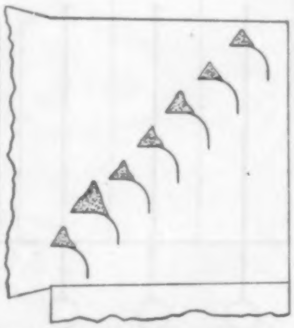


Fig. 11—Front view showing fly-ash buildup on turning vanes above air heater, No. 7 boiler, Station No. 10, Aurora, Ill.



End view showing maximum fly-ash buildup

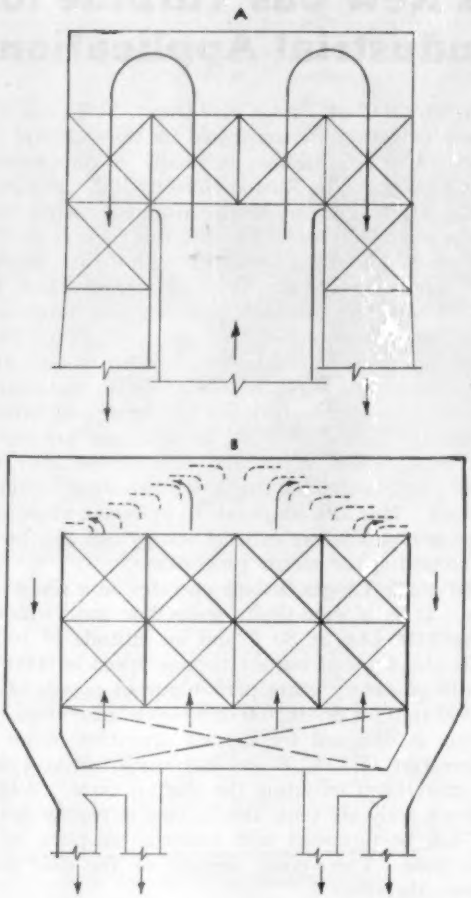


Fig. 12—Original design (above) and design after rebuilding (below)

air heater has been heated as high as possible with steam bled from the turbine, so the stack temperatures actually run at 325 to 350 F.

Under this more favorable condition, the dust outlets at "*A*" were all 100 per cent plugged. The gas outlets were only completely plugged on a small percentage whereas this whole area was largely plugged on the first inspection on both the dust and gas outlets and on some of the inlets.

The cyclone separators at "*B*" were in better shape on the first and second inspections, largely due to the ability of the operating group to hand lance the dust outlets through the access door "*D*."

The "*A*" cyclone separators empty in a small hopper and discharge through pipe "*C*" to the large hopper, hence there is no chance with such an arrangement to lance the cyclones in this section.

Washing Equipment and Wire

The boilers which are now being engineered will be so designed that the fire side of the tubes can be washed at intervals of say once each year. On one such occasion, the moisture from the furnace condensed in the air heater and dust collector, wetting the ash that remained, so that shorts occurred which could not be cleaned until the next outage. With this experience in mind, it is the plan to so design the last boiler purchased, so that all equipment from the burners to the stack can be washed. This is a large order, but our engineers believe it can be done. With everything washed clean, including the dust collector, it is believed that condensation occurring in starting, will evaporate again without shorting out the collector.

The Edison Company's precipitator installations contain various types of high tension wire. There is square iron, twisted square iron, stainless steel ribbon, stainless steel round, and round iron. There may be considerable merit in the theory that the corona from the sharp edge of a straight or twisted square iron is more intense than for other shapes, or that the flutter of a ribbon will keep that type of wire clean without the aid of vibrators. In actual practice, the dust buildup on any of them can be sufficiently heavy to nullify all such good points. For units collecting dust from Central Illinois coals such as Edison uses, the high tension wire will collect varying amounts of dust, depending upon fineness of grind and velocity, and temperature of the gas. It appears from inspections made during the past year that the smooth surface of a round stainless steel wire will shed the dust better than the other types and that they can be more vigorously vibrated for dust removal purposes without excessive breakage.

It also appears that for the ash from these same coals, that it is very essential to equip the high tension frame with a rapping device that can remove such buildups.

Perforated Discharge Plates

Inspections show varying degrees of buildup on these plates. Some have been found with their gas passage area over 50 per cent plugged. The uniform gas flow through the collector must be seriously upset under such conditions. This condition calls for two things. First, the plate should be spring mounted and sectionalized, so that it can be vibrated, and second, some type of device will need to be employed that will remove the dust at regular intervals, possibly once each shift or once each day. Possibly the magnetic-impulse rapper is the device to accomplish this.

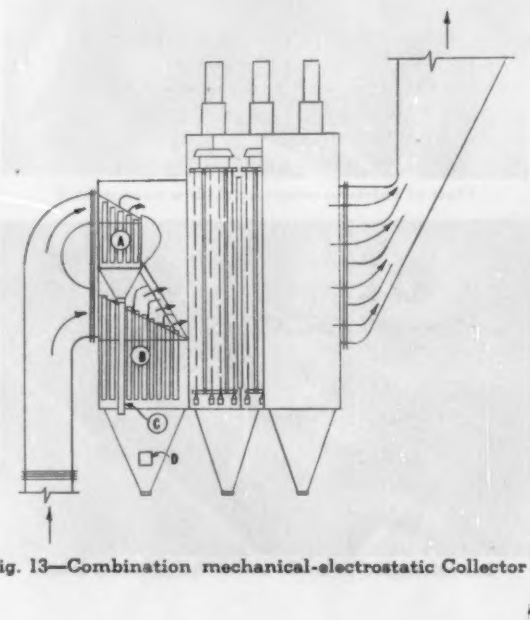
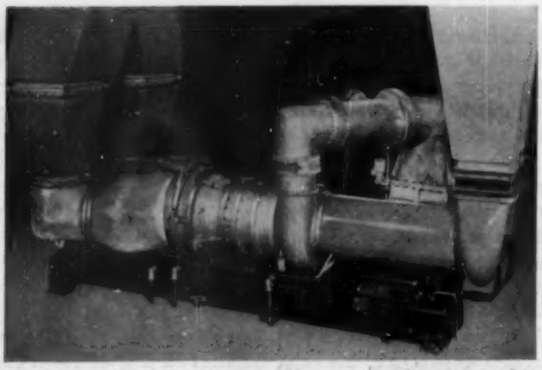
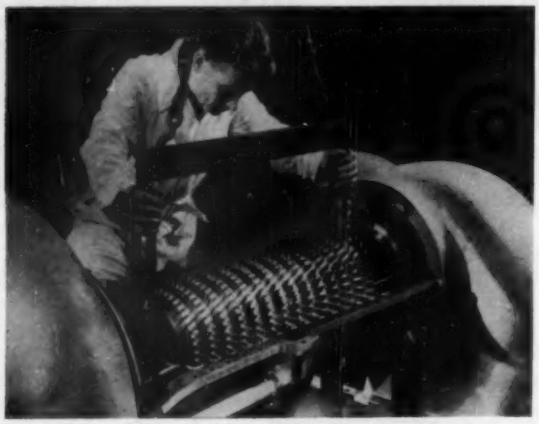


Fig. 13—Combination mechanical-electrostatic Collector E


Installation view showing simple support for gas turbine


Turbine and stator readily accessible as shown


View of thirteen-stage axial-flow compressor

A New Gas Turbine for Industrial Applications

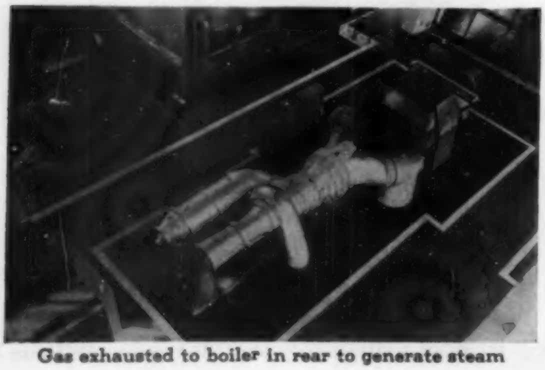
On July 26 Clark Bros. Co. of Olean, N. Y., one of the Dresser industries, demonstrated for the technical press an 1130-bhp gas turbine originally manufactured in Lincoln, England, by Ruston-Hornsby Ltd. Designated as the Mark TA, the newly acquired design, which is to be manufactured and sold in this country by Clark Bros. under a licensing agreement with Ruston-Hornsby, is in many respects similar to the larger Clark Type 302, an 8500-bhp gas turbine which was developed in 1955 (see COMBUSTION, August 1955, pp. 54–55).

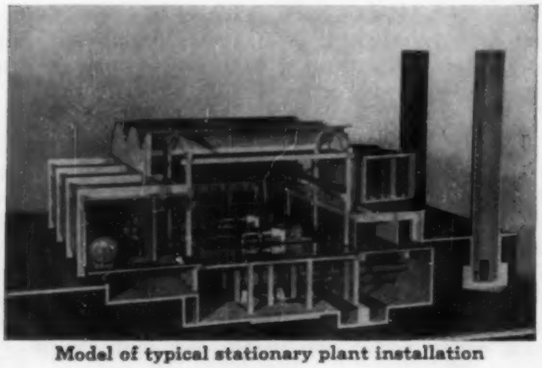
The new unit, of which 40 have been or soon are to be placed in operation, is well suited to stationary or portable power generation and to marine and industrial mechanical drives. Typical areas of use are gas and fluid transmission where the variable-speed or high-starting torque characteristics of a two-shaft turbine are required. It is also adaptable to processes where power is required and where exhaust energy can also be used for preheating or steam generation.

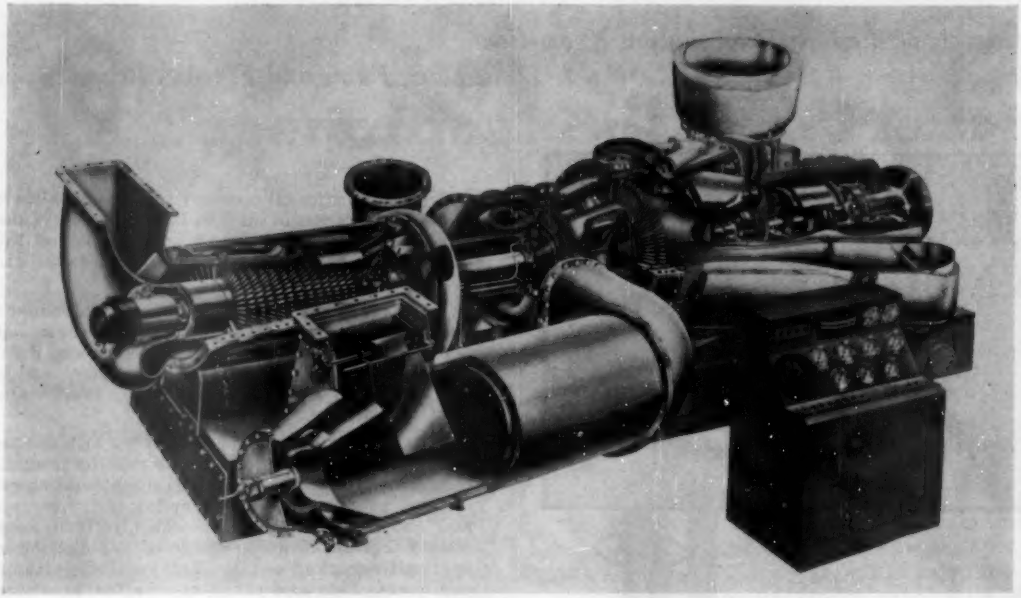
The Mark TA gas turbine operates on a simple open cycle. It is a dual-shaft, series-flow unit which develops 1130 bhp at 80 F and an altitude of 1000 ft. While the nominal output turbine speed is 6000 rpm, built-in planetary gears permit output speeds of 1500 or 1800 rpm for driving 50 or 60-cycle generators. The turbine is designed for normal operation at an inlet temperature of 1340 F and can reach full load within two minutes of initiating the startup cycle. Weighing approximately six tons, the turbine is readily portable and can be furnished with either a one-piece or two-piece base. Three-point support of the unit assures proper alignment.

Features shared in common by the Mark TA and the Clark 302 gas turbines include a single combustion chamber, air cooling, long life and easy accessibility. Combustion air is supplied by a 13-stage axial flow compressor at a pressure ratio of 4.0 and a flow of approximately 22 lb per sec, the compressor being driven by the high-pressure turbine at approximately 11,500 rpm. Combustion takes place in an elbow-type combustion chamber with a single burner.

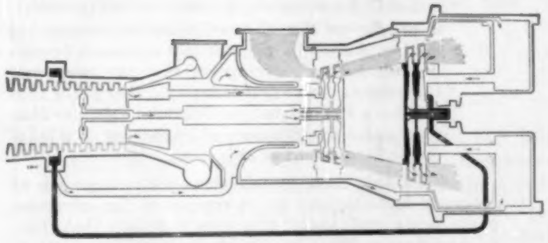
Starting is accomplished by turning a single hand wheel. It was apparent at the Olean demonstration that a relatively unskilled operator could start the gas turbine merely by turning this hand wheel and checking on several temperature and flow meters.


Gas exhausted to boiler in rear to generate steam

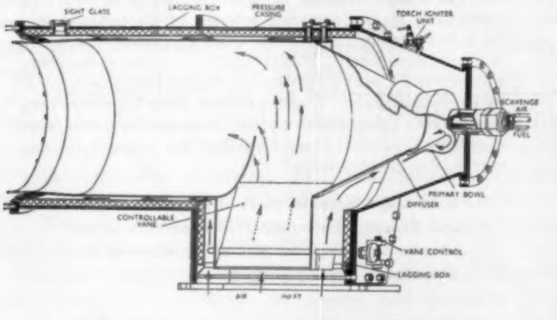

Model of typical stationary plant installation



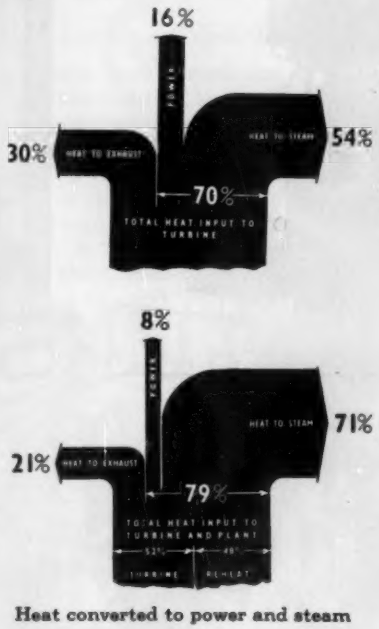
Cutaway view of Mark TA gas turbine; control panel at right



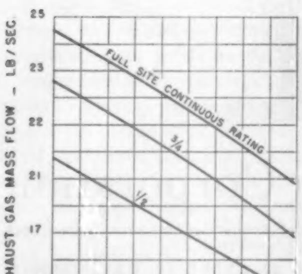
Arrangement of air cooling system



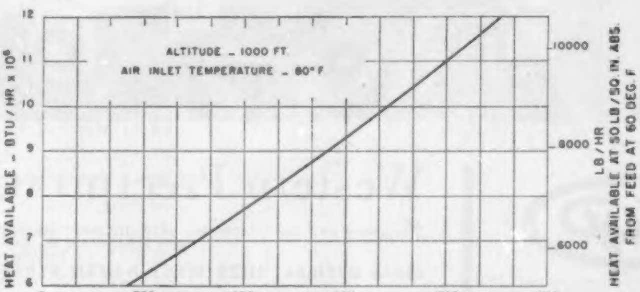
Single combustion chamber and burner



Heat converted to power and steam



Exhaust gas heat recovery



Available process heat or steam with power generation

Another example of Western Precipitation Know-How
in Dust, Fume and Fly Ash Recovery . . .

When a major oil company recently installed a new fluid cat cracker in the Salt Lake area, one of the first considerations was for efficient clean-up of the stack gases to protect against detrimental air pollution.

So the problem of final clean-up was brought to the organization that has more know-how, more widespread experience in recovering dusts, fumes and fly ash from industrial gases than has any other organization...Western Precipitation Corporation.

And this job, like most recovery installations, had its special problems that made *experience* an all-important factor. For one thing, space requirements dictated an extremely close coupling of the recuperator and recovery equipment—which, in turn, necessitated that an advanced design of gas distribution system be worked out by Western Precipitation engineers. This and other unique features were incorporated into this COTTRELL Precipitator to insure optimum clean-up efficiencies.

Result...final clean-up provided by the COTTRELL *is so efficient that the outlet loading is only 9½ lbs./hr. Although air pollution codes are becoming increasingly stringent, this far surpasses the nations most rigid codes—further proof that Western Precipitation* COTTRELLS *deliver that vital extra performance so important on a long-range investment of this type.*

This Salt Lake installation—not a large job as recovery installations go—is typical of the advanced engineering and careful attention to details that characterize *every* Western Precipitation installation, from the smallest to the largest. Western Precipitation know-how extends back over almost 50 years of leadership in the complex science of dust, fume and fly ash recovery . . . and includes COTTRELL *electrical* recovery equipment, MULTICLONE *mechanical* recovery equipment, CMP *combination* electrical-mechanical recovery equipment and DUALAIRE *filter* type recovery equipment. *You get an unbiased recommendation from Western Precipitation—backed by know-how unmatched in the industry!*

In all major industrial areas of the United States and Canada, this unsurpassed experience is as close as your telephone. May we be of service on your current recovery problem?

COTTRELL Electrical Precipitators
MULTICLONE Mechanical Collectors
CMP Combination Units
DUALAIRE Reverse-Jet Filters
HOLO-FLITE Processors

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Avon No. 8
A Supercritical Pressure Plant*

By C. A. DAUBER

Director of Civil and Mechanical Engineering Division
The Cleveland Electric Illuminating Company, Cleveland 1, Ohio

This article describes the 250,000-kw supercritical pressure addition to the Avon Plant of The Cleveland Electric Illuminating Company. Special features of the third supercritical pressure unit designed for an American central station include the use of a monotube once-through boiler, combination motor and turbine-driven boiler feed pumps, extruded pipe for main steam leads, condenser bypass demineralization system and a high-temperature water heating system for the plant addition.

THE Cleveland Electric Illuminating Company has four generating plants and serves a 1700-square-mile area in northeast Ohio. This year the Company is observing its 75th anniversary, its earliest predecessor having been founded in 1881 by the celebrated arc-lamp pioneer, Charles Francis Brush. Growth of both Company and area is indicated in these words spoken during the official ground-breaking for the new unit by the Company's president, Elmer L. Lindseth: "In 1881 the Illuminating Company's earliest ancestor, The Brush Electric Light and Power Company, had one steam generating unit which when run at full capacity would light a total of 88 lamps. When the new unit begins operation at Avon, the Illuminating Company will be able to turn out a total of two million kilowatts. . . . This will be two and one-half times our generating capacity at the close of World War II."

This tremendous load growth has been a challenge to the Company's engineers to design and construct the most efficient and economical generating plants. The recent breakthrough of the critical pressure barrier for steam and water provided a new tool for higher thermal efficiency, but it also brought along a host of intriguing problems in such fields as high-temperature metallurgy and boiler feedwater conditioning. This paper is being written to attract the interest of young engineers who may not be aware that electric power generation is an area of technology which has achieved, in the case of The Cleveland Electric Illuminating Company, a reduction in fuel consumption from 6 lb per kwhr to 0.67 lb per kwhr in the past 75 years. To these young engineers, as well as to those more experienced in central station design and operation, it is hoped that the information will convey some of the challenge that faced engineers of our Company when initial announcement was made in the summer of 1955 that Unit No. 8 for the addition to Avon Plant was to employ a supercritical pressure steam cycle.

Since emphasis in this paper is on unusual features of design, many details duplicating conventional central station practice will not be discussed. All aspects of the design had not been "frozen" at the time of preparation of the manuscript, so some portions may be subject to future revision. It was thought that a greater contribution to central station practice could be made by sharing information at this time than by waiting until the station begins operation.

Site Location and Cycle Selection

Extensive studies were carried out to establish the location of the 1958 addition, its optimum size, and the most economically desirable steam conditions. Site location involved a choice between a recently purchased location on the Ohio River and several sites in various stages of development within the Company service area. Strong consideration was given to the advice of the U. S. Defense Department to locate the unit outside of the Cleveland metropolitan area as a part of the policy of plant dispersal. By choosing to extend the Avon Plant, located twenty miles west of downtown Cleveland, it was possible to obtain a Certificate of Necessity for a five-year amortization on 65 per cent of the plant investment. Careful analysis

Fig. 1—Plot plan of Avon addition

*Paper presented at ASME Semi-Annual Meeting, Cleveland, Ohio, June 17–21, 1956, under auspices of Power Division.

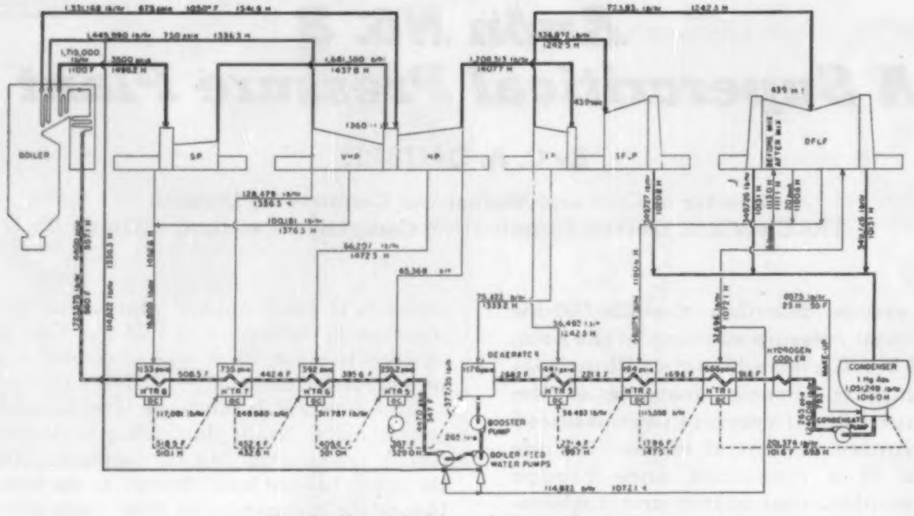


Fig. 2—Simplified heat balance diagram

of the cost factors involved indicated that the saving in coal delivery charges for the river site were not as yet sufficient to overcome the added fixed and operating charges associated with a high-voltage transmission line from the Ohio River to the Company service area. On the other hand, the Avon site did not involve comparable transmission line costs, and it was found that the use of money made available by the deferral of taxes through rapid writeoff overcame all other economic factors and justified the selection of the existing station site on Lake Erie as the preferred location.

Selection of unit capacity size involved a study made in conjunction with the Operations Research Staff of Case Institute of Technology. An analysis of system reserve requirement, both with respect to maintenance and reliability, was carried out. This phase of the study resulted in the sizing of the unit at 250,000-kw and confirmed the in-service date of late 1958. The Company established a forced-outage probability requirement of "no more than one deficiency in generating capacity in five years."

A number of heat cycles ranging in throttle pressure from 2400 to 5000 psig and in temperature from 1050 to 1200 F were selected for consideration. Preliminary calculations narrowed the range to 3000–3500 psig and 1050–1100 F, with single reheat to 1050 F. Because

Fig. 3—Plant cross section

of anticipated design and operating problems with steam at pressures just below the 3202 psia critical pressure, it was decided to move through this range to 3500 psig. Furthermore, the Company's policy is to select steam conditions one step in advance of the most economical unit in order to contribute to the advancement of the art. In dealing with one turbine manufacturer, it was found that ferritic materials could be used to withstand 1100 F main steam temperature. For these reasons, throttle steam conditions of 3500 psig, 1100 F were selected with reheat to 1050 F.

Space limitations, together with electrical cost factors, dictated the selection of a tandem-compound unit. These considerations were influenced by the location of the new unit in an existing plant. The new extension to the Avon site will be as shown on the plot plan in Fig. 1.

The layout of the Avon extension is of the fully enclosed "ranch-type" with the turbine-generator shaft oriented parallel with the front face of the steam generating unit as shown in Fig. 3. This is the best arrangement, since the physical dimension of the tandem-compound turbine-generator along the centerline of the shaft will be 108 ft. Walls for the station extension will be constructed of insulated stainless steel panels with brick pilasters.

There will be a centralized control room for all boiler and turbine controls. This air-conditioned control room will be designed to accommodate two units and will be located directly between the turbines and boilers on the turbine operation floor level. Main electrical controls will be located in an existing control room installed at the time of the construction of the original section of the station.

Fig. 2 shows a simplified heat balance diagram for this unit. The estimated net plant heat rate at rated load and back pressure is 8620 Btu per kwhr with two steam-turbine-driven boiler feed pumps in service. With one turbine-driven and one motor-driven feed pump in service, the plant net heat rate will be reduced to 8605 Btu per kwhr.

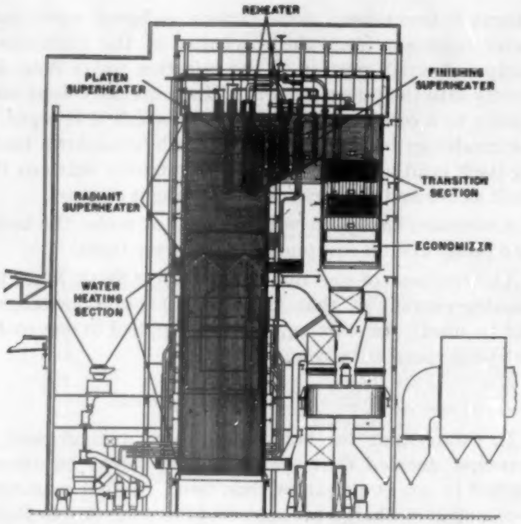


Fig. 4—Boiler cross section

Steam Generator

Steam will be supplied to the 250,000-kw supercritical pressure turbine by a C-E Sulzer monotube steam generator as shown in Fig. 4. It will be a pulverized-coal-fired unit of the dual-furnace design as manufactured by Combustion Engineering, Inc., and corner firing using tilting tangential burners will be employed to burn low-ash-fusion-temperature coal. The unit will be designed to deliver 1,715,000 lb of steam per hr to the turbine throttle at 3500 psig and 1100 F with single reheat to 1050 F. The boiler has no drum and is of the forced-circulation once-through type. In many respects it is similar to Sulzer monotube units in operation in European power plants. The main boiler feed pump furnishes sufficient head to force the boiler water through the continuous-tube circuits of the various sections of the boiler as well as the feedwater and main steam lines.

The feedwater, after leaving the two parallel lines of feedwater heaters, is divided into a total of four circuits. Two feedwater circuits supply an economizer for each furnace. The feedwater flow to the economizers is controlled in each circuit by individual feedwater control valves. The feedwater then flows to the water walls which occupy approximately the bottom half of the wall surface in each furnace. No conventional downcomers outside of the boiler are required to supply the water wall section. The boiler water makes a number of up-and-down passes in the furnace water wall section before entering the horizontal tube transition zone which is located in a relatively cool convection region. The transition zone is where water is converted into steam. As will be discussed later, very careful control of feedwater quality is maintained to prevent the deposition of solids in the transition zone or superheater.

Each of the two steam circuits per furnace, on leaving the transition zone, is subdivided into two parallel circuits through a series of radiant, platen, and finishing superheaters. These eight steam circuits include appropriate stop and bypass valves, which are used during startup and abnormal operating periods. To maintain uniform steam temperature distribution to the turbine, the leads from the stop and bypass valves are connected into a mixing header.

In developing a logical and balanced design, it was necessary to obtain variations from some of the arbitrary rules in today's Boiler Codes. This is due to the fact that the Codes as written did not have this type of boiler in mind. All the variations have not been thoroughly developed and approved by the Industrial Commission of Ohio. However, as an example, the safety valve capacity cannot be located on the drum as there is no drum. Therefore, it is intended that all safety valve capacity will be located at the superheater outlet and the safety valves will be set above the operating pressure, so that they will not affect operation unless the automatic control and bypass valves do not function. Thus, safety valves are even more in the category of occasional departures than is the normal case on utility boilers.

Turbine-Generator

The Westinghouse turbine-generator, a cross section of which is shown in Fig. 5, is designed for a maximum throttle flow of 1,715,000 lb of steam per hr at a pressure of 3500 psig and temperature of 1100 F with reheat to 1050 F. With two turbine-driven boiler feed pumps in service, the maximum capability of the main turbine is 250,000 kw. The 3600-rpm innercooled generator has a rating of 273,460 kva at 22 kv, 0.85 power factor, 0.64 short-circuit ratio and 45-psig hydrogen pressure. Provision is made to operate the generator at 60 psig. A 1200-kw exciter driven by a 1750-rpm induction motor operating at 375 volts supplies excitation current.

The tandem-compound, triple-flow turbine receives supercritical pressure steam which at full load is expanded to 2000 psia in the steam-cooled "super pressure" section. The steam then passes to the "very high pressure" section where its pressure is reduced to 750 psia. Reheated steam returns to the "high pressure" turbine at 1050 F where it expands to 240 psia. After passing through the "intermediate pressure" turbine, the steam enters the triple-flow "low pressure" sections at 45 psia. The design condenser pressure is 1.0 in. Hg.

The entire control and protective system on this turbine is hydraulically operated. The main steam controls include servomotors for moving the governor valves which determine the flow to the turbine, the speed-responsive governor, and the speed changer which adjusts the speed range in which the governor will control the servomotors. The interceptor valves are closed during startup and up to a steam flow of 30 per cent of maximum.

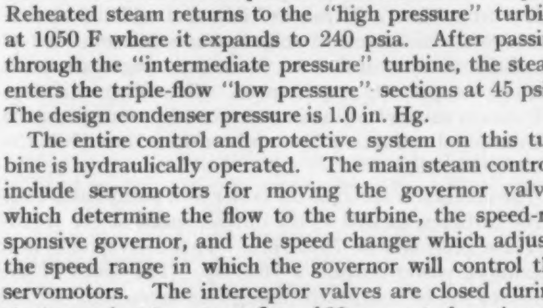


Fig. 5—Turbine cross section

The protective system includes the main steam throttle valves, the reheat stop valves, the overspeed trip valve and its connected devices for tripping the main steam throttle, the governor, interceptor, and reheat stop valves whenever the turbine reaches a predetermined overspeed. A load-limit device is also provided to limit the maximum opening of the governing valves to any chosen amount. In addition, the turbine is protected against low vacuum and low oil pressure. The throttle and reheat stop valves have only two positions: closed or fully open.

The governing valves function in parallel to allow full peripheral admission of steam to the first stage of the turbine. As a result, therefore, the throttling loss at partial loads will be greater than for machines where the governing valves open sequentially.

Although the final complement of supervisory instruments has not yet been decided upon, it is likely that several new ones will be added to those normally utilized on subcritical machines. In accordance with current practice on the system, provision is being made for remote control of the turbine-generator.

By maintaining the same turbine-room width for the station extension, it will be possible to use the existing 125-ton crane in the new section. An additional 175-ton crane will be installed with the new turbine. Current plans are to have the generator shipped as a completed unit weighing approximately 625,000 lb. Both the existing and the new crane will be used to transfer it to the turbine-generator supporting foundation.

Boiler Feed Pumps

There will be three six-stage main boiler feed pumps each capable of delivering 2285 gpm (1,026,000 lb per hr) at a total head of 11,580 ft. Two of the pumps will be driven by steam turbines and the third by two 4000-hp motors in tandem.

The two boiler-feed-pump-drive turbines will receive steam from the "cold reheat" line and will deliver exhaust steam to the lowest stage extraction line. Part or all of the steam will flow to the lowest stage extraction heater to supply its requirement. The balance, if any, will return to the turbine in a reverse direction from the conventional extraction flow, and continue through to the main condenser.

The maximum speed of the boiler feed pumps and their drive turbines, as well as the output speed of the speed-increase gear, will be 7575 rpm. This corresponds to a maximum power output of 7650 hp. The speed of the turbines will be controlled through a conventional flyball governor with speed changer. Impulses will be received by the governor through a hydraulic system from the feedwater regulating valve. The output of the two motors in tandem will be delivered to the pump through a hydraulic coupling speed-increase gear.

It is tentatively planned to control the speed of the motor-driven pump from a governing device mounted on the speed-increase gear. The output signal from a hydraulic system will position the speed regulating tube of the hydraulic coupling which will, in turn, match the output speed of the electrically driven pump and that of either or both of the turbine-driven pumps.

These pumps are equipped with labyrinth breakdown bushings in place of the conventional shaft packing. This labyrinth breakdown arrangement is based upon cold water injection from the discharge of the condensate pump. A small portion of the injection water flows inwardly into the pump proper. The remainder flows outwardly to a collection chamber from which it is piped to the condenser hotwell. The labyrinth breakdown bushing itself is adjustable, so that concentricity between the shaft sleeve and the breakdown bushing is assured.

A common base plate will be installed under the boiler feed pump and all equipment in the drive train.

The purpose of the dual motor drive is to limit the starting current so that standard 4000-volt switchgear can be used. In starting, power is applied to one motor until full speed is reached.

Choice of Pump Arrangement

In establishing the boiler feed pump arrangement, it was first decided that such pumping would be accomplished in one stage rather than two. With a maximum feed pump discharge pressure of 4730 psig, it was found that the savings in pump power in handling relatively cool water (339 F) exceeded the savings which would have resulted from designing the high-pressure feedwater heaters for a lower pressure. The use of such lower pressures for heater design would have been permitted by the addition of a second stage of feedwater pumping. This would have supplied something in the order of 50 per cent of the pumping requirement after the feedwater had left the highest pressure feedwater heater. The added cost of two sets of pumps, as compared with one, was another factor pointing toward a single stage of pumping. As a result, all feedwater pumping will be accomplished in one stage ahead of the high-pressure heaters in the conventional manner. To assure adequate NPSH to the boiler feed pumps at all times, low power booster pumps are arranged to receive feedwater from the deaerator and deliver it to the main boiler feed pumps.

The equipment and controls are being designed so that any two or three of the pumps can operate in parallel satisfactorily. Present expectations are that the two turbine-driven pumps will be capable of operating in parallel down to 30 per cent of full load.

Feedwater Heaters

The four high-pressure feedwater heaters will be designed for a water-side pressure of 4730 psig. Since these four heaters are located on the discharge side of the boiler feed pumps, it has been necessary to establish their operating pressure to meet the pump discharge pressure required to deliver 3500 psig steam to the turbine throttle. The three low-pressure condensate heaters will be designed for 300 psig, the maximum discharge pressure of the condensate pumps. The deaerating feedwater heater will be designed for 125 psig. In addition to the feedwater heaters, a hydrogen cooler, condensate cooler, and gland steam cooler will be located in the condensate cycle. A steam regulator will control the flow of steam to the gland cooler. A diagram of the condensate and boiler feedwater cycle is shown in Fig. 6.

After study of the cost factors involved, it was decided to employ two heaters in parallel for each of the high-pressure feedwater extraction stages. Cost factors considered in this study included: cost of the heat ex-

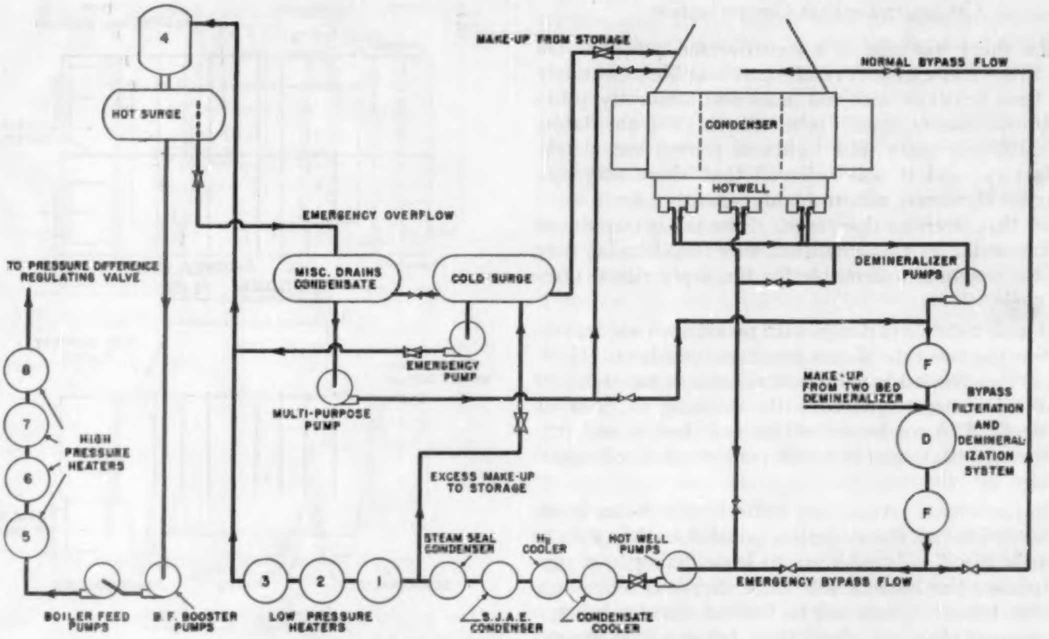


Fig. 6—Condensate and boiler feedwater cycle

changer, piping cost, valve cost, and space evaluation for each of the arrangements. With two strings of heaters, it was deemed unnecessary to design piping for bypassing an individual heater. As a result, a difference in valving costs assumed significant proportions. Should any high-pressure heater require maintenance, that entire string of heaters will be taken out of service. It is hoped that it will be possible to carry almost full load under this condition.

The high-pressure heaters are of the U-bend type with integral desuperheaters and drain coolers. Each of the drain coolers will be designed for a 10 deg F approach to the temperature of feedwater entering the heater. Tubes will be of 15 BWG minimum wall Monel, welded to the tube sheet.

The low-pressure heaters are the conventional U-tube design including integral desuperheaters and drain coolers. The second lowest pressure heater will be located in the condenser neck. All units are designed with integral tube sheets and channels with separate removable channel covers. As in the case of the high-pressure heaters, all low-pressure heaters are equipped with 10 deg F approach drain coolers. Tubes in the low-pressure heaters will be of 18 BWG admiralty metal.

Original plans had called for the drains of the lowest pressure heater to be pumped into the condensate stream between the first and second lowest pressure heaters in order to obtain the best possible heat rate. After consideration of water-conditioning problems, however, it was decided to send these drains directly to the condenser. The possibility of significant copper and iron pickup by the extraction drains in cascading through the low-pressure heaters made it desirable to demineralize low-pressure drains as soon as possible.

The deaerating feedwater heater consists of two vertical steel sections equipped with spring-loaded spray valves and deaerating element. These deaerating heater sections, with internal direct-contact vent condensers are mounted on, and supported by, a horizontal cylindrical steel storage tank of 6200 cu ft capacity.

Water Quality Control

The once-through supercritical pressure boiler design imposes stringent limitations on total solids in the boiler feedwater. Solids formerly blown from the boiler drum can lead to deposit formation in the unit if not removed by other means. Solids in the steam may deposit on the turbine blades.

In the latest 2400-psig controlled-circulation boiler at Eastlake Station, the feedwater pH is maintained at 9.0 to 9.2 by adding morpholine or ammonia. Feedwater conductivity (undegassed) of 1.0 to 1.5 micromhos is satisfactory. In the supercritical pressure cycle, the feedwater will have the following limitations:

pH 9.0–9.5 . . . . by adding ammonia or hydrazine
Total solids . . . 50 ppb maximum at condensate pump discharge
Total iron . . . . . 10 ppb maximum
Total copper . . 10 ppb maximum
Silica . . . . 20 ppb maximum
Oxygen . . . . 7 ppb maximum

A condensate bypass filtration and demineralization system will be used to maintain the solids within the required limits. The bypass filtration and demineralization system serves three major purposes: (1) protect feedwater cycle from condenser tube-sheet weepage (leakage between tube and tube sheet) and condenser tube rupture leakage, (2) "polish" makeup water from a two-bed demineralizer system, and (3) remove corrosion products from the cycle.

Two secondary purposes of the bypass filtration and demineralization system are (1) "polish" miscellaneous drains before returning to the cycle, and (2) cleanup of the cycle on original startup and following outages.

Condenser Leakage Contamination

Tube sheet weepage is a controversial subject. On Lake Erie water excellent results and long life expectancy have been achieved with red brass and admiralty tubes rolled into muntz metal tube sheets. On the latest 1800–2400-psig units tube tightness proved completely satisfactory, and it was believed that there was zero leakage. However, recent highly sensitive tests have proved that weepage does exist. The solids introduced into the water by this condition were found to be more than the maximum allowable for the supercritical pressure cycle.

A double tube sheet design with pressurized condensate between the two tube sheets was first considered. However, it was decided for practical reasons to use standard rolled tube sheets sprayed with neoprene to promote tightness. The condenser and hotwell designs will permit demineralization of 95 to 100 per cent of all tube sheet weepage.

The condenser, rectangular hotwell, and water boxes will be divided on the centerline parallel to the tubes as shown in Fig. 7. In addition to loose fitting tube support plates, the hotwell will have divisions transverse with the tubes. These will be located directly below a tube support plate and about 18 in. below a tube support plate. The transverse divisions have been provided in order that 95 to 100 per cent of any tube weepage will be caught in the four end sections of the hotwell. Normally all water in the four end sections will be sent to the bypass filtration and demineralization system. The effluent from the bypass demineralization system will be sent to the center section of the condenser for redeaeration by the condenser before the water is returned to the cycle. The full load design flow for the bypass system is 625,000 lb per hr or 50 per cent of condenser flow, including low-pressure heater drains.

The bypass filtration and demineralization system has been designed for 100 per cent condenser flow during emergency operation. Tube rupture will be detected at the hotwell pump by precise conductivity measurements. When abnormally high conductivity is detected, all condensate will be sent through the bypass filtration and demineralization system. By designing the bypass system for 100 per cent condenser flow, the unit can hold full load for 24 hours or longer with no danger of cycle contamination. By comparison to other supercritical pressure plants, the amount of stored high-purity water (358,000 lb) is relatively small.

Longitudinal divisions of the condenser and hotwell have been provided to determine on which side a condenser tube has ruptured. In this case also, conductivity measurements on each of six outlet nozzles of the hotwell will indicate the location of tube rupture. The circulating pump on the side in which failure occurs can be turned off, permitting the water box to be drained. With one side of the condenser out of service the turbine load will be reduced to approximately 70 per cent. At the same time the water box can be drained and the end of the ruptured tube plugged, after which the unit may be operated at full load.

Makeup Water

Raw water makeup to the cycle will be processsed through a two-bed demineralizer equipped with a vacuum degasifier. This makeup is polished in the mixed-bed demineralizers which are a part of the condensate bypass system.

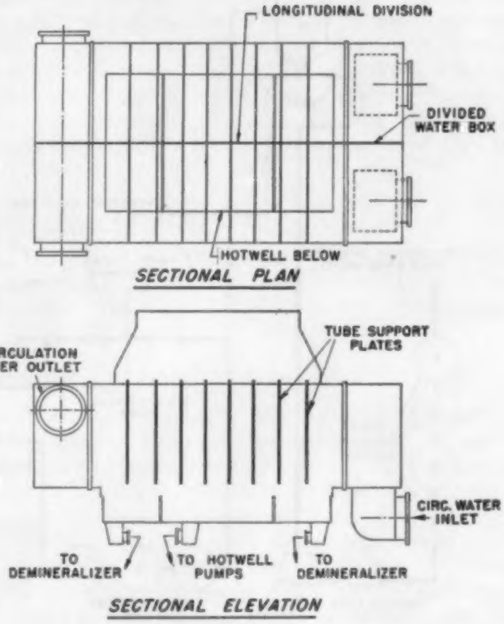


Fig. 7—Condenser arrangement

All other sources of condensate makeup at the station can be utilized by processing through the mixed-bed bypass demineralizer. These include evaporated makeup from the adjacent boilers and stored condensate.

Prevention and Removal of Corrosion Products

The cycle has no special materials, such as stainless steel or rubber-lined pipe, to prevent corrosion. Control of pH by the addition of ammonia or hydrazine at the hotwell condensate pump and deaeration of the condensate will be relied upon to protect the metals in the preboiler cycle. The system is equipped with a standard condenser with deaeration guaranteed to 0.03 cc. of oxygen per liter (43 ppb) and a deaerating heater with deaeration guaranteed to 0.005 cc of oxygen per liter (7 ppb). The high-pressure heater drains are returned to the deaerating heater. The low-pressure heater drains will be returned to the end sections of the hotwell for bypass polishing.

The filters ahead of the bypass polish demineralizers will be relied upon to remove the corrosion products in the condensate. The nature of the filter material has not been established but work is in progress to determine experimentally the most desirable filter material. Post-demineralizer filters will be used to remove traces of resin and elutriated materials from the ion-exchange beds.

Power Piping

The main steam piping for this unit, shown diagrammatically in Fig. 8, presented problems not previously encountered on conventional subcritical pressure units. Eight main steam leads of $6^5/_8$ in. O.D. × 4 in. I.D., (ASTM Specification A-312, Grade TP316, austenitic

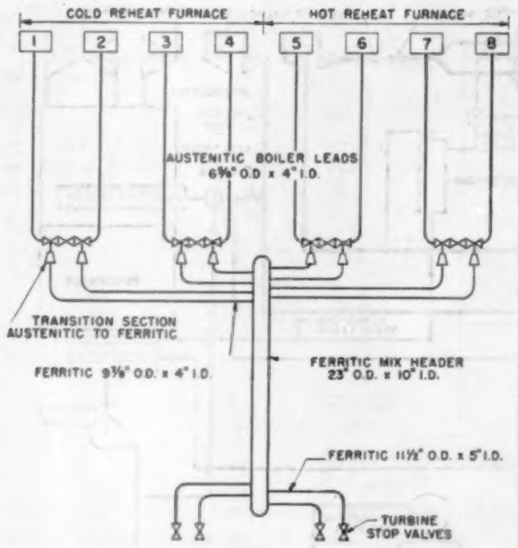


Fig. 8—Diagram of main steam piping

material) were established from the superheater outlets to the boiler stop valves. Each of these leads is approximately 300 ft long.

On the turbine side of the boiler stop valves, a transition section of austenitic to ferritic material will be used. There will be no change in wall thickness at the weld at this point. The ferritic material ($2^1/_4$ Cr. 1 Mo.) ASTM Spec. A335, Grade P22 or $2^1/_4$ Cr-1 Mo-$^1/_4$ Va will be used from the transition section through a ferritic mixing header (approximately 23 in. O.D. × 10 in. I.D.) and then four ferritic leads ($11^1/_2$ in. O.D. × 5 in. I.D.) to the four turbine stop valves.

Due to the operating conditions of 1100 F at the turbine throttle, it was possible to have a metallurgical choice between ferritic or austenitic alloys. Tests were performed on Types 316 and 347 in coarse and fine grain specimens by heating a 20 in. length of small diameter heavy-wall pipe to 1440 F, clamping, and then cooling to 1200 F to obtain plastic strain. The conclusions of these tests indicated that the hot ductility of *fine grain* Type 316 is much better than coarse grain materials. These facts led to the decision to specify relatively thin wall fine grain austenitic pipe for the eight main steam boiler leads. It is proposed that the required pipe will be manufactured by the extrusion method of a *fine grain* material with the same manufacturing tolerances as "seamless" for which the wall-thickness variation is plus or minus $12^1/_2$ per cent. The normal 0.065-in. corrosion allowance was included in the pipe wall calculations. The lengths available from the extrusion press in the 4 in. I.D. size up to $1^1/_2$-in. wall are approximately 30 ft.

By procuring long lengths the welded joints will be kept to a minimum. Root pass welds in the main steam line will be made using the inert-gas tungsten-arc method combined with the use of consumable backing rings. This procedure utilizes a shielded-arc to draw an inert gas-backed ring into the joint to form a first-pass bead completely fused with the parent metal and without any crevices. The welds are to be made without preheating. All the welds will be ground flush and inspected by radiography and fluid-penetrant methods.

Design pressures and stress allowances were determined for the main steam piping from the superheater outlets to the boiler stop valves (under jurisdiction of the Boiler Code) by taking the turbine throttle pressure of 3500 psig, 1100 F and adding a design allowance of 5 per cent plus the calculated pressure drop in the piping, valves, and mixing header back to the superheater outlet headers from the turbine stop valves.

The resulting superheater outlet header design pressure was approximately 3950 psig at 1110 F, and all pipe wall calculations for the austenitic materials were determined on this basis. The stress allowance of Grade TP316 was interpolated for 1110 F temperature.

The low velocity of 9100 ft per min through the main steam leads became necessary to minimize an already large pressure drop in the piping and valves of approximately 275 psig. From the boiler stop valves through the mixing header to the turbine stop valves, the ferritic main steam leads were designed under the ASA B.31.1 Piping Code, and varying design pressures with 1100 F temperature were used.

The boiler feedwater piping was designed by utilizing the higher allowable stress present in the *new* ASTM Spec. A-106, Grade "C." Due to reluctance of domestic mills to roll Grade "C" carbon steel pipe, the order was placed in Germany.

Boiler Control Systems

The once-through boiler has five control systems:

(1) Feedwater regulation
(2) Main steam temperature
(3) Turbine bypass system
(4) Combustion control
(5) Reheat temperatures

In terms of conventional American boiler practice, the turbine bypass control system is the most unusual feature necessitated by the once-through design. The feedwater regulation is based on temperature rather than on drum level.

Hydraulically operated controls will be employed for the feedwater, main steam temperature, and turbine bypass system as shown diagrammatically in Fig. 9. These will be similar to those with which a great deal of experience has been had in subcritical once-through boilers in Europe.

Combustion control to adjust fuel and air supply in accordance to load will be of electro-pneumatic design. Many new features, such as matching firing rate to generator load and air flow corrected by oxygen content of flue gas, are being contemplated.

Reheat steam temperature control will be of electrical design. Since reheater surfaces exist in each of the two furnaces, the temperature control will have two stages. Burner tilt temperature control will be employed in each furnace. The final reheat temperature will employ sprays for desuperheating as backup protection.

A brief description of the boiler heating surfaces is necessary to understand the basic controls. The boiler has four separate circuits, each consisting of an economizer, water walls, transition section, radiant superheater, platen superheater, and finishing superheater. The individual parallel circuits extend from the pressure-difference regulating valves to the mixing header just before

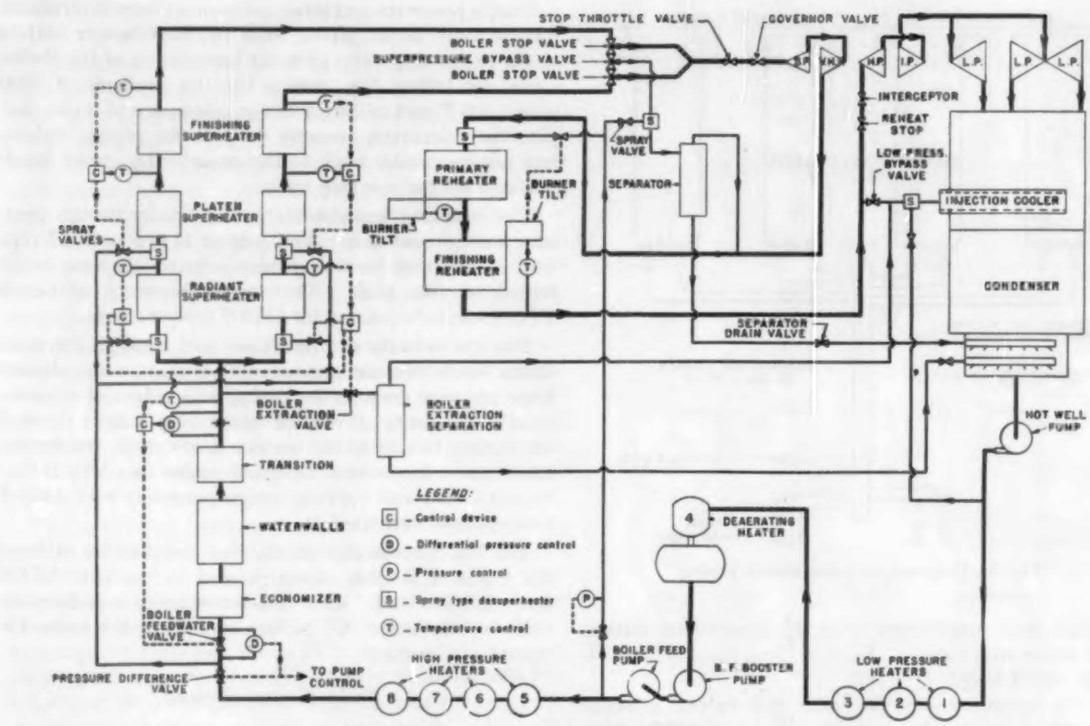


Fig. 9—Boiler control and turbine bypass cycle

the turbine throttle. Each circuit has independently controlled valves to regulate feedwater flow, boiler extraction, spray water for steam temperature control, and flow to turbine or flow around turbine to the reheater.

Feedwater flow in each of the circuits is controlled by the steam flow nozzle and the temperature leaving the transition zone. The steam flow nozzle is used as an anticipation device and the final control is provided by temperature. Maintaining the proper temperature at the outlet of the transition zone matches feedwater flow to firing rate.

The pressure-difference regulating valve is used to maintain an approximate 30 psi drop across the feedwater regulating valve. The use of the pressure-difference valve compensates for variation in feed pump pressure and boiler pressure so that the feedwater flow depends exclusively on the position of the feedwater valve.

The speed of the feed pumps is regulated by the position of pressure-difference valves. If the flows are slightly unbalanced in the four circuits, one of the pressure-difference valves will be opened slightly more than the others. The pump speed will correspond to pressure-difference valve open the widest. In this manner the pumps will be running fast enough to maintain proper flow in each of the four circuits.

The main steam temperature in each circuit is regulated in two stages by means of spray type desuperheaters located at the inlet of the radiant superheater and at the inlet of the platen superheater. Each of the two steam temperature controls functions essentially alike.

The spray at the inlet of the radiant superheater is controlled by the temperature leaving the radiant superheater with anticipating impulse from the temperature leaving the transition zone.

The spray at the inlet of the platen superheater is controlled by the temperature leaving the finishing superheater with anticipating impulse from the temperature leaving the platen superheater.

The spray water for each circuit is taken from the line between the feedwater valve and the pressure-difference valve. The flow of spray water varies with the flow of feedwater prior to adjustment by the two-element temperature control.

Provision has been made for extracting water from the system at the outlet of the transition section, the purpose being to reduce the flow through the superheater during unusual operating conditions. The three primary functions of the boiler extraction system, which is controlled by the same two-element temperature control as the spray valve at the inlet of the radiant superheater, will be to operate during loss of fire, under conditions of extremely low load, or during a hot restart. The use of this extraction system will limit sudden temperature reduction in the high-temperature superheater and piping on loss of fire, or make it possible to maintain proper temperature suitable for the turbine during hot restart.

The boiler extraction valves, which are located in each circuit after the transition zone, discharge to the condenser and will be locked closed on a cold start. Interlocks prevent the valves from opening if the condenser cannot condense the steam without excessive temperatures.

The turbine bypass system is required for cold starts, hot restarts, turbine trips, and abnormal operating conditions. Flow of steam or water bypasses the turbine through the superpressure bypass valve in each circuit as shown in Fig. 9. The superpressure bypass valves discharge into a separator. The water from the separator

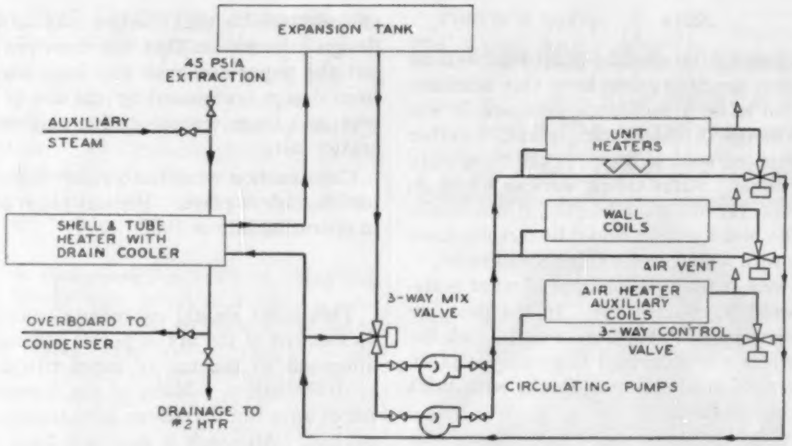


Fig. 10—High-temperature water heating system

is discharged into the condenser. The steam from the separator discharges into the cold reheat lines. The steam travels through the reheater out the low-pressure bypass valves on the hot reheat lines. The steam from the low-pressure bypass valves discharges into the injection cooler on the neck of the condenser. The steam at the superpressure bypass valve outlet is sprayed to keep the temperature equal to cold reheat temperature. The steam in the injection cooler is sprayed to limit the turbine exhaust hood temperature.

The primary function of the boiler stop valves in each circuit is to prevent water from entering the turbine. On cold startup, water is pumped through the entire boiler to the condenser through the separator. Only when proper steam conditions are established will steam be admitted to the turbine.

The combination of the superpressure bypass valves and boiler stop valves also prevents steam from entering turbine at temperatures excessively above or below those allowable at any given time. The bypass valve also acts as a relief valve which will open at 105 per cent pressure.

High-Temperature Water Heating System

The conventional low-pressure saturated steam for coil and general building heating could not economically be used because of the absence of saturated steam from a boiler drum and the desirability of minimizing makeup of high-purity feedwater required for the boilers. Therefore, a high-temperature, closed-cycle forced-circulating hot water system was selected as shown diagrammatically in Fig. 10. It permits greater flexibility in pipe runs, smaller size of pipe, and the elimination of trap maintenance.

To obtain high-temperature water, superheated steam will be extracted from the cycle at the 45 psia stage and passed to an ordinary feedwater heater-type heat exchanger equipped with a drain cooler. The condensate will then flash to the No. 2 low-pressure heater. In the high-temperature water circuit, a pump will continuously circulate water at approximately a constant flow rate through the heat exchanger and on through the air heating coils and unit heaters. In general, control will be provided by a thermostatically-controlled bypass valve to bypass water around the heat exchanger. A spare pump will be provided.

For starting up Unit No. 8 and for heating the building loads 30 per cent or lower or shut-down periods, steam will be provided via a pressure-reducing station from the boiler drums of Units 6 or 7.

Combustion Air Preheating

The current practice of reducing building cubage to a minimum and the constant effort to increase plant efficiencies requires a carefully engineered method of introducing combustion air into the building.

The combustion air will be drawn through wall louvers and heating coils at a low elevation in the precipitator bay. The air rises to the top of the boiler house absorbing approximately 75 per cent of the boiler and equipment radiation losses which amount to approximately 1.5 per cent of the boiler input. From the top of the boiler house, the air will be drawn down through large air shafts which are connected by ducts to the forced draft fans.

A portion of the combustion air will be drawn through a 30-ft deep air well, through heating coils by a large centrifugal fan and discharged into the turbine room basement near the feedwater heaters.

The balance of the building heating will be supplied by thermostatically controlled unit heaters.

Auxiliary heating coils will be installed in the air inlet side of the air heaters to maintain proper air inlet temperature during startup and during low load.

Air Conditioning and Ventilation

The boiler control room, the relay room, the electrical control room and the laboratory will be air conditioned. Fresh air will be taken from outside the plant and a positive pressure will be maintained in the control rooms to permit occupancy in case of fire in the plant.

Roof ventilators, gravity type, will be installed on both the turbine house and boiler house. The turbine house ventilators will be motor operated and manually controlled. The boiler house ventilators will be opened automatically whenever the air shaft temperatures exceed 135 F. Both sets of ventilators will have fusible links with weighted dampers set to open in case of fire permitting positive escape of high-temperature gases and smoke and preventing failure of the roof structure.

Stack

One of the problems in the existing plant has been air pollution. In order to determine how this addition could be constructed to be a minimum nuisance, it was decided to test a model of the existing plant, together with one of the proposed new addition, in the New York University wind tunnel. After trying various locations for the new stack and various stack heights, it was finally determined that the best location would be directly back of the boiler house with a height of 400 ft above grade.

Several studies were made to determine of what materials the stack should be constructed. In the past, extensive use had been made of steel stacks with brick linings. However, when it was decided to go above 300 ft, it was found that reinforced concrete stacks with brick linings were more economical.

The substructure for the stack is a 42-ft octagonal concrete pad of maximum depth of six ft. The stack tapers from 28 ft O.D. in the base, to 18 ft, 6 in. O.D. at the 400-ft level. Thickness of concrete varies from 1 ft, 9 in. at the base to six inches at the top. The stack will be lined with four inches of dense brick and will have one-inch Fiberglas insulation to separate the brick from concrete.

Job Status

Engineering work on the supercritical pressure addition to Avon Station began in August, 1955. As was mentioned earlier, the entire design has not been completely established at the time of the writing of this paper. Some studies are still being made, and therefore it is entirely possible that changes may be made in some of the design information that has been presented. Throughout the paper emphasis has been placed on departures from design occasioned by the use of supercritical pressure in a large central-station single boiler-turbine-generator unit.

Construction work has already begun, and some of the footings are in place. Present plans are to have the unit in operation late in 1958.

Conclusions

This plant should contribute considerably to the advancement of the art of power generation. It is a third approach to the use of supercritical pressure in large central stations. Many of the features described in the paper have not heretofore been incorporated in any other project. Although it does not have the best projected heat rate, it appears at present to be the most logical selection of steam conditions in the supercritical pressure range. This is evidenced by the fact that others are now contemplating units operating in the 3500-psig range.

Acknowledgments

The author's thanks are due to his colleagues in the Civil and Mechanical Engineering Division, principally Messrs. H. L. Colgin, R. L. Dombey, N. F. Gill, R. W. Ott, S. B. Rock, R. B. Shumaker, C. D. Trump, and G. H. Walker, who contributed information for the final manuscript, and to the several manufacturers who co-operated in the preparation of the paper.

ASTM Announces Review Committee for Water Testing

Nine organizations, according to the American Society of Testing Materials in a news release dated June 15, became charter members of a new Joint Committee on Uniformity of Methods of Water Examination at a meeting in Biloxi, Miss., on January 26, 1956. Since that date, another has joined the group. The recommendations of this committee will be advisory only and will not supplant or impede the work and publication policies of any participating interest.

The purpose of the committee is to secure uniformity of content of these methods by providing a mechanism for exchanging information among member organizations; securing uniformity of terminology; and reviewing methods with respect to objectives, sampling, apparatus and reagents, procedure, reporting of results, and application. The methods reviewed will include those covering natural water, potable water, industrial water, industrial waste water, and sewage.

Charter members include the Committee on Disposal of Refinery Wastes of the American Petroleum Institute, American Public Health Association, American Society of Mechanical Engineers, American Society for Testing Materials, Association of Official Agricultural Chemists, Federation of Sewage and Industrial Waste Associations, Manufacturing Chemists Association, Technical Association of the Pulp and Paper Industry, and the United States Public Health Service. The Geological Survey (U. S. Dept. of the Interior) was elected to membership on April 24, 1956.

Special Television Camera Featured at German Industry Fair

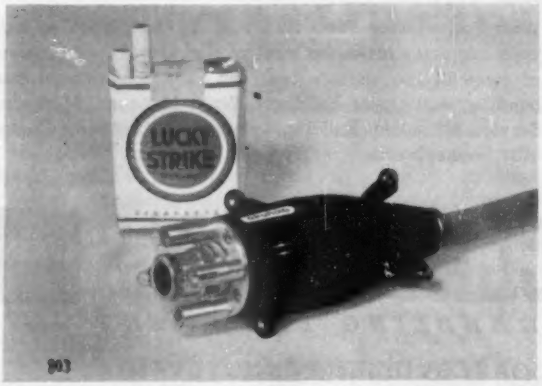
Last year's Radio and Television Exhibition in Duesseldorf displayed an especially handy and small television camera for industrial television traffic control and scientific investigations. This camera produced by the Grundig Radio Works of Füerth, Bavaria, employed for its size advantage a small tube, just developed, the "Mini-Resistron" which measured 3.5 in. long and 0.59 in. in diameter.

Later according to the VDI Nachrichten, May 26, 1956, the Grundig Works were asked to develop a television camera which could be used to inspect the inside of boiler tubes and piping. For such service a flexible television camera had to be developed which could move within a tube like a "salamander." The new miniature pictured on the cover is the result. With only about 5.9 in. length and a diameter of 1.85 in. it proved to be a special attraction at this year's German Industry Fair at Hannover.

In its special form for tube inspection the camera is fitted with spring-loaded guide-casters at its side and with four lights at its front to illuminate the inside tube wall. In this form the camera can be used for inspection of tubes with a minimum inside diameter of 2.36 in. It can even look "around corners" since it can be moved through bends with 13.8 in. radius.

The "remote inspection" of the inside tube wall is done with the help of a small mirror mounted about 0.71 in. ahead of the fixed lens furnished by the firm Schneider, Bad Kreuznach. The tube wall is lighted by four lamps arranged around the lens. The optical image is transformed into electrical impulses and transmitted by cable to the receiver. The tube wall visible on the picture tube of the receiver can be enlarged 20 times which is required for the short focal distance of only 5 in. of the lens. The test engineer will learn to "read" a tube wall picture as fast as doctors do when studying X-ray pictures. This application of a camera for industrial television is completely new and not even known in the U. S.

In its standard form this smallest television camera in the world is also furnished without guide casters and lamps. It further features a so-called "rubber lens" in which focus, range adjustment and lens opening can be continuously varied by remote control. A tilting and turning head can also be operated by remote control. Thereby the "tele-eye" considerably increases its field of vision covering a horizontal angle of 320 degrees and a vertical angle of 60 degrees.



Above photo gives comparative size of "Tele-eye"

Still another installation of Lukens 20% Type 304 stainless-clad steel coal handling equipment . . . this time at Picatinny Arsenal, Dover, N. J.

Engineering Educators Meet at Iowa State College

AT THE 64th Annual Meeting of the American Society for Engineering Education held at Iowa State College in Ames on June 25–29, **Maynard M. Boring,** president of the Society and consultant on engineering manpower for the General Electric Co., set forth a five-point program to increase the nation's resources of engineers and scientists through more effective education. The demands of industry clearly indicate that quality rather than quantity is needed. We in this nation have become hysterical concerning this manpower problem, according to Dr. Boring. Secondary education holds the key to increasing the numbers and competence of engineering graduates. The educational process in the engineering colleges is dependent on the maturity and the basic foundation of the product of our public schools. During this century, our public schools have been forced into an educational program that is geared to the average youngster. The teaching of mathematics and science has degenerated enormously. While technology has been imposing a greatly expanded, broadened, and deepened engineering education, there has been a decrease in the amount of vital subject matter available in the public schools. The gap between the secondary schools and the colleges has been seriously widened.

These are the steps which Dr. Boring recommended:

1. We must increase the efficiency of our educational program. Approximately 50 per cent of the students qualified for professional work do not go beyond the high school. And we lose nearly 50 per cent of those who start professional work in college.

2. Engineering colleges should stiffen their entrance requirements, to assure that their entering students will be better prepared and can progress faster, and as a means of encouraging higher standards throughout secondary education.

3. High schools and colleges alike should greatly improve their guidance activities. Proper guidance and the stimulation needed to develop each youngster to the limit of his capabilities has been seriously neglected both in the public schools and in the early stages of the undergraduate collegiate days. Dr. Boring suggested that guidance be extended to the junior high school level; students having decided at this stage on their future professions are still young enough to take the proper courses in high school to prepare them for their collegiate work.

4. Financial resources for education must be improved. Funds must be provided for sufficient numbers of well-trained, dedicated teachers at a good economic level, proper equipment for demonstration and laboratory use, and adequate modern buildings. Since taxpayers are already burdened, industry will have to help.

5. The professional recognition of teachers must be achieved early in their careers. The future of our technology lies in the hands of young teachers, and we must find a procedure whereby they can reach their fullest development. This is the group who can break away from tradition, who have the most intimate contact with the students, and who undoubtedly have the most influence on the younger members of our profession.

Science in Engineering Teaching

Speaking specifically of adding modern physics to engineering studies, **Dr. William L. Everitt,** dean of the College of Engineering at the University of Illinois, said that there is today no justification for any confidence that traditional ways of thought will long be adequate for professional use in engineering. Engineering educators have been slow to face the profound revisions which the contributions of modern physics require in our thinking about energy sources and power conversion, about materials and structures and their uses. Physics research has been responsible for such new engineering tools as electron microscopes, fluorescent tubes, and transistors and semi-conductors. If these did not shatter the complacency of engineers, Dean Everitt said, the dramatic applications of atomic and nuclear power provide absolute evidence that fresh areas of knowledge must be added to the standard equipment of all graduates in engineering. Even more important than the actual accomplishments to date is the certainty that this demonstrated progress will continue and will become increasingly important in the future.

Engineers can no longer neglect their responsibility to meet such new engineering requirements as these. The intensity and rate of scientific progress in these fields demands that engineering education take swift action to add these areas of knowledge to their programs. One can predict confidently that industry must and will change at an ever-greater rate as an outgrowth of new scientific and engineering developments. Engineers and scientists who understand the complex fundamentals of science and engineering upon which new industrial developments are based will have of necessity a growing part in the top management of successful corporations.

Engineering educators must accept this challenge: they must efficiently and economically absorb in present engineering curricula a great mass of new essential knowledge; this must be done in all courses and from all points of view. Specifically, engineering teachers must constantly strive to integrate physics research findings into all engineering instruction.

Dr. Richard B. Adler of the Massachusetts Institute of Technology emphasized the growing rôle of science in all phases of modern life and pointed out that it must accordingly have a growing share of the educational experience of any well-educated man. Indeed, because science and its applications—engineering—are not completely separable, some engineering, too, will automatically be a part of all science education. Undergraduate engineering education should be a very special case of this modern education: it should emphasize science heavily, not only because science is the backbone of creative engineering but because it has general educational value as well. Science in undergraduate engineering education should certainly include as much as possible of any and all branches of knowledge about natural phenomena which have reached the stage of very considerable quantitative organization, and should include the mathematics required to understand them.

Including as much as possible of this kind of science in undergraduate engineering education would leave the graduate in a position of maximum flexibility. He would be in the unique position of being ready to apply quickly whatever may develop out of current scientific research.

Humanities and Social Studies in Engineering Education

Engineering educators agree that their students need a fuller acquaint-

ance with the humanities and social sciences, but some fear the effect on already-crowded curricula. However, a number of leading engineering colleges already have developed programs to provide sound experience in the humanities and social sciences which simultaneously reinforce their students' engineering training. Others, studying this experience, should be able to make major improvements. The ASEE has recently completed a major study of the rôle of humanities and social studies in engineering education. The report declared that the engineer is not adequately prepared to make an effective contribution in today's world if he has not acquired during his undergraduate study some sense of human values and some knowledge of the social, economic, and political world in which he will play a conspicuous part.

Commenting on the problem and on the Society's report, **Dr. Harry P. Rogers,** president of the Polytechnic Institute of Brooklyn, said that engineers everywhere want students who are joining the profession to have an understanding of the evolution of the social organization in which we live and the influence of science and engineering on its development. This would also imply that they should possess a knowledge of the economic forces and operations fundamental to our American industrial economy. It furthermore implies that they should have an understanding of man himself, on his nature in terms of intellect, beliefs, what he holds as important, and his motivations, attitudes and behavior, as well as his expressions in literature and the arts.

Dr. Rogers said it would be futile to try to achieve this end by selecting standard courses from the departments of English, history, economics, sociology, and psychology. Instead, he urged engineering faculties to help develop better courses especially for engineers, working closely with the instructional staffs in the areas where desired courses may be taught. He criticized engineers who prescribe ability in English for their students but who fail to demonstrate that ability themselves. Indeed, he argued, if the engineering student is to achieve the understandings, abilities, and powers which we philosophically prescribe, the members of the instructional staff must possess these themselves.

Prof. Edward W. Comings of Purdue University made a plea for more careful planning and more enthusiasm in incorporating liberal courses into technical curricula in order to insure the interest of the student. He advocated a planned series of courses, with enough flexibility for experimentation and development of new programs.

The rise of anti-intellectualism was noted by **Prof. S. R. Watson** of the Fenn College, Cleveland. The engineer is a product of the modern climate of opinion, and he in turn helps form it. Obviously, he must assume responsibility for his part. In order to do this, he must understand this climate and be aware of its flaws and weaknesses. Now at the time when the scientist and engineer seem to be in control of our climate of opinion, there are signs of revolt apparent in the rise of anti-intellectualism. The engineer's world is founded upon reason, upon the intellect. As educators involved in engineering education we need to alert the engineer to the dangers of anti-intellectualism, to make him aware of his need for the pure scientist and for the humanist. Then and only then will he have found himself, his place in society, and his significance in the evolution of civilization.

Loss of Engineering Teachers

The engineering colleges of the United States have experienced a net

loss of three per cent of their teaching staffs to industry within the past two years, at a time when rapidly increasing enrollments made it most necessary that the staffs be enlarged.

This serious situation was reported by **A. R. Hellwarth,** assistant to the director of employment at the Detroit Edison Company, who headed a committee which made a survey for ASEE after Dean J. F. Downie Smith of the Iowa State College Division of Engineering, reported last year on the possibility of an alarming migration of faculty members to industry in the face of a growing shortage of engineering graduates. The survey showed that engineering colleges need 1300 more teachers to carry the 1956–1957 load, or about 15 additional for every hundred now teaching. During the two-year period of the survey, 750 left engineering faculties for industry while 500 left industry for teaching, leaving a net loss to the colleges of about three teachers in every 100. Higher salaries in industry were cited as the chief reason. Some of the former teachers left to seek greater opportunities and new experiences. The crying need is for young engineering teachers, and many deans lament their inability to retain a greater number of students who have obtained advanced degrees. These, traditionally, have formed the core of the nation's engineering teaching force.

Industry representatives, who met with educators at a session to consider this problem were frank in pointing out that industry is giving a better deal. According to **R. N. Dyer**, head of the personnel division of the Humble Oil and Refining Company, it is a known fact that individuals employed in engineering and scientific activities in industry not only start at salaries higher than those in the teaching profession, but, quite frequently, ultimately receive greater financial reward. He also pointed out that colleges were lagging in providing the many fringe benefits which are constantly being added to industry. He criticized the practice of basing pay increases on the number of degrees held, or on length of service. Cost of living and productivity formulas are better able to encourage superior performance and to permit a policy of promotion from within.

An influence of extreme importance is broader recognition which industry affords by allowing professional and technical men to advise on management decisions and by placing them in top managerial jobs, according to Mr. Dyer. In order to insure the continued strength of higher education, we must not only increase the financial reward to teachers, but we must

secure greater acceptance of them as a truly important segment of our professional society, giving them the recognition and prestige they so richly deserve.

R. C. Smith, general supervisor of salaried personnel for the Allison Division of General Motors Corp., said he believed that most of the nation's responsible industry feels it is unethical to woo engineering teachers from their college assignments. Allison and General Motors, as well as other industries, have attempted to cooperate with colleges by hiring engineering teaching personnel for summer advisory work, and by providing conferences and institutes in which teachers would be interested. Smith admitted, however, that sometimes teachers hired for "temporary" work have asked to be retained.

On the other hand, colleges offer some very real advantages in the opportunity to work and shape the lives of many young people, in freedom of working hours, in a literate and stimulating atmosphere and in attractive locations, argued **Dean William T. Alexander** of the College of Engineering, Northeastern University. "It is high time in my opinion that we as teachers stopped deprecating our profession and began to advertise its very real advantages," he said. "Why not indicate that we are proud of it?—for we really are."

New Officers

Dr. William L. Everitt, dean of the College of Engineering at the University of Illinois, will be the new president of the American Society for Engineering Education. **Cleo A. Brown,** administrative assistant to the president of the General Motors Institute, was elected vice president for the Society's instructional division activities. The Society's new treasurer is **John Gammell,** director of graduate training at the Allis-Chalmers Manufacturing Company.

New Books

Any of these may be secured by writing Combustion Publishing Company, 200 Madison Avenue, New York 16, N. Y.

Industrial Purchasing

By J. H. Westing and I. V. Fine

John Wiley & Sons, 421 pages, $7.50

Subtitled "Buying for Industry and Budgetary Institutions," this book originated from discussion between the Milwaukee Association of Purchasing Agents and the faculty of the School

of Commerce of the University of Wisconsin. Professors Westing and Fine were appointed editors and worked in collaboration with two committees appointed by the Association to prepare an outline for the book and select contributers for individual chapters. Thus the book represents a combination of the viewpoints of the operating purchasing executive and the more generalized academic approach, all molded into a prearranged pattern and subjected to extensive editing for a consistent style.

The subject matter of the book includes such topics as organization and procedures for purchasing, selection of sources of supply, quality control, traffic procedures, forward buying and speculation, legal aspects of purchasing, management reports and public relations in purchasing goods.

One especially interesting chapter relates to the purchase of major equipment. Very often several departments are concerned with the purchase of such equipment, and as an example the authors cite the differences in purchasing a carload of fuel oil as contrasted to the purchase of a turbine-generator. Mention is made of the importance of vendor service in connection with installation and startup of major equipment, and some consideration is given to the purchase of used equipment and its leasing.

Although this book is on the fringe of most activities in the steam power field, it will give those engineers who are willing to take the time to read it a new insight into the many and varied functions of purchasing departments of industrial organizations and government procuring agencies.

Commercial and International Developments in Atomic Energy

Atomic Industrial Forum, 598 pages, $8.50

This paper-bound publication includes the proceedings of a meeting held in Washington, D. C., in September 1955 in conjunction with the first U. S. Trade Fair of the Atomic Industry. A report of the meeting appeared in October 1955, COMBUSTION, pp. 69–76.

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